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REPORT ON THE MISSOURI RIVER BASIN FOR THE PRESIDENT'S WATER RESOURCES POLICY COMMISSION

Public Health Service, Kansas City, Missouri

May 1950

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A description of the Missouri River Basin is provided. For purposes of reporting the physiographic characteristics, the Basin is divided into six parts and each is discussed in depth. Included is a discussion of the sources of pollution in the Missouri River Basin, water use, and the adequacy of water for the indicated use. The need for abatement of pollution in the Basin is emphasized, followed by a discussion of specific policy problems.

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REPORT ON

THE MISSOURI RIVER BASIN

for the

PRESIDENT'S WATER RESOURCES POLICY COMMISSION

Prepared by the

Missouri Drainage Basin Office
Division of Water Pollution Control

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TABLE OF CONTENTS

PART I

Page

Missouri River Basin - General 1
  Introduction 1
  Sources of Pollution in the Missouri River Basin 2
  Water Use and Adequacy of Water for Indicated Uses 2
  Need for Treatment Works 3
  Conclusions and Recommendations 5

Missouri River Sub-divisions
  Upper Missouri River Sub-division 8
    Description of Sub-division 8
    Sources of Pollution 10
    Water Use and Adequacy of Water for Indicated Uses 11
    Need for Treatment Works 12

  The Yellowstone River Sub-division 15
    Description of Sub-division 15
    Sources of Pollution 18
    Water Use and Adequacy of Water for Those Uses 19
    Need for Treatment Works 19

  Minor Tributaries Sub-division 22
    Description of Sub-division 22
    Sources of Pollution 25
    Water Uses and Adequacy of Water for Indicated Uses 26
    Need for Treatment Works 27

  Niobrara, Platte and Kansas Sub-division 29
    Description of Sub-division 29
    Sources of Pollution 32
    Water Use and Adequacy of Water for Indicated Uses 33
    Need for Treatment Works 35

  The Lower Missouri River Sub-division 41
    Description of Sub-division 41
    Sources of Pollution 43
    Water Uses and Adequacy of Water for Those Uses 44
    Need for Treatment Works 45

Page

Fort Peck to Sioux City Sub-division 55
  Description of Sub-division 55
  Sources of Pollution 57
  Water Uses and Adequacy of Water for Those Uses 58
  Sewage Treatment Needs 59

PART II

Benefits and Costs 63

PART III

Specific Policy Problems 66
  Specialized Problems Involving Project and Program Plans, Including That of Coordinating the Interest of Several Agencies Within the Basin 66
  Resolution of Apparent Conflicts Between Upstream and Downstream Interests in the Use of the Water Resources of the Basin 68
  Sediment Problems 69
  Need for Mosquito Control Measures in and Around Hydraulic Works 70
  Need for Improved State Legislation Relating to the Control of Pollution 70

MAPS

No.			Following Page No.
1.	Missouri River Basin..................	Principal Sub-divisions	1
2.	Missouri River Basin..................	Sources of Pollution	14
3.	Missouri River Basin..................	Existing Water Uses	14
4.	Yellowstone Basin.....................	Sources of Pollution	21
5.	Yellowstone Basin.....................	Existing Water Uses	21
6.	Minor Tributaries.....................	Sources of Pollution	28
7.	Minor Tributaries.....................	Existing Water Uses	28
8.	Niobrara, Platte & Kansas Rivers.....	Sources of Pollution	36
9.	Niobrara, Platte & Kansas Rivers.....	Existing Water Uses	40
10.	Lower Missouri Basin.................	Sources of Pollution	47
11.	Lower Missouri Sub-division..........	Existing Water Uses	54
12.	Fort Peck to Sioux City Sub-division.	Sources of Pollution	60
13.	Fort Peck to Sioux City Sub-division.	Existing Water Uses	62

MISSOURI RIVER BASIN

PART I

MISSOURI RIVER BASIN - GENERAL

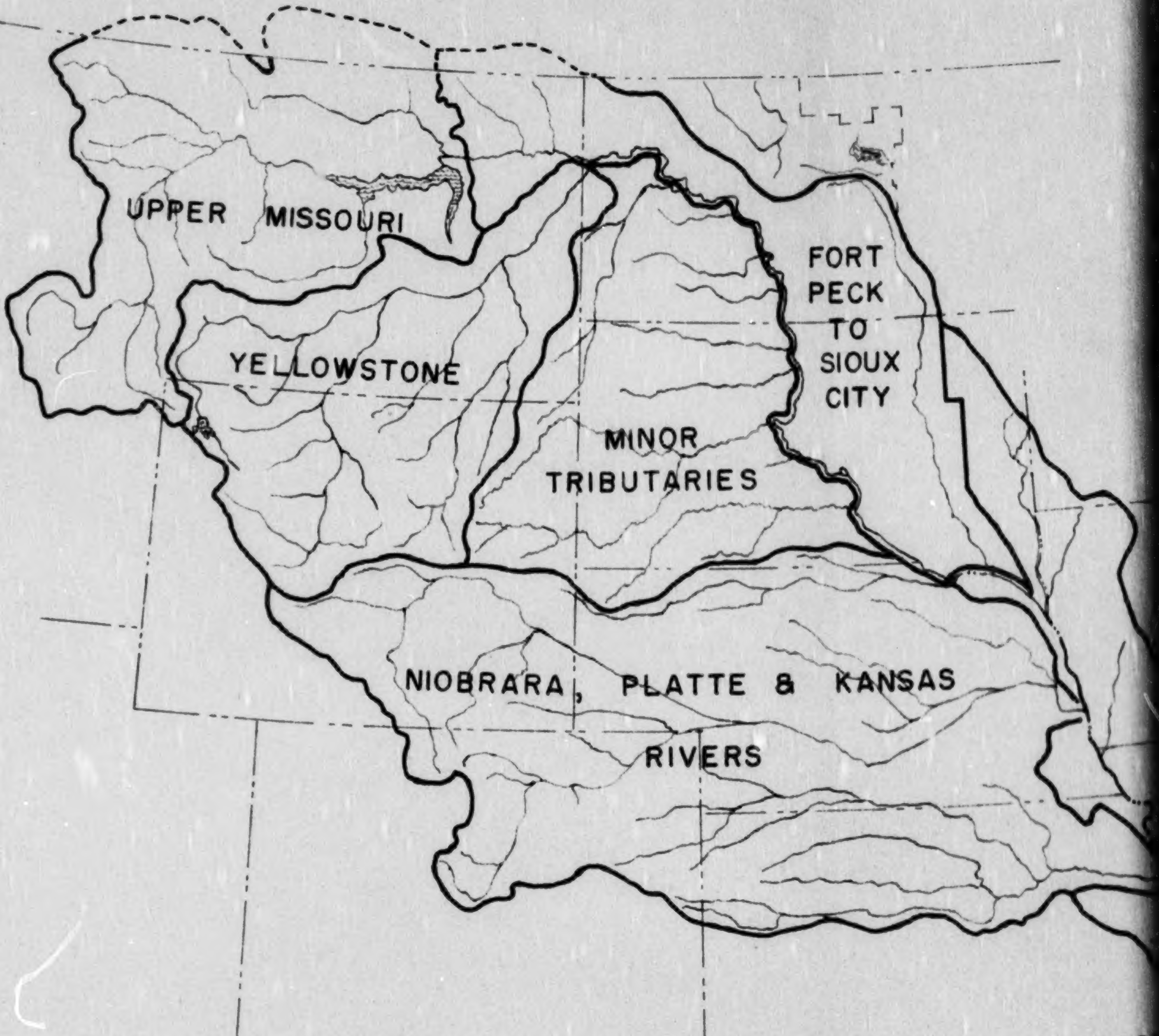
Introduction

The Missouri River Basin lies between the 90th and 114th meridian west and between the 37th and 50th parallels north. The area, with a maximum width of approximately 700 miles and 1300 miles long, occupies parts or all of the States of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri, and Minnesota, and encompasses 530,000 square miles. Natural bounds are formed by the Rocky Mountain uplift on the west, the Hudson Bay Drainage Basin to the north, the Mississippi Drainage Basin on the east, and the Ozark uplift and Arkansas River Basin to the south. The main stem of the Missouri River, formed by the junction of the Jefferson, Gallatin, and Madison Rivers near Three Forks, in the Rocky Mountains of western Montana, extends 2,550 river miles to its mouth at a point just above St. Louis, Missouri. Major tributaries include the Yellowstone, the Platte, and the Kansas Rivers. Numerous other tributaries flow into the river throughout its entire length.

The physiographic characteristics of the Missouri Basin are sufficiently varied to justify its division, for reporting purposes, into the six following parts: (1) the Upper Missouri River Sub-division, which lies almost exclusively in Montana; (2) the Yellowstone Sub-division located in the States of Wyoming and Montana; (3) the Minor Tributaries Sub-division which includes sections of North Dakota, Wyoming, and South Dakota; (4) the Niobrara, Platte, and Kansas River Basins, containing portions of Wyoming, Colorado, Nebraska, and Kansas; (5) the Lower Missouri River Sub-division which includes portions of Missouri, Kansas, Nebraska, South Dakota, Iowa, and Minnesota; and (6) a Sub-division known as the Fort Peck to Sioux City Division, which includes the main stem of the Missouri River, the James and Vermillion Rivers, and other tributaries in North Dakota and South Dakota, as well as the Souris and Devil's Lake Region of North Dakota. These Sub-divisions correspond closely to those used by the Bureau of Reclamation, U. S. Department of the Interior, and are shown pictorially on Map No. 1.

MISSOURI RIVER BASIN

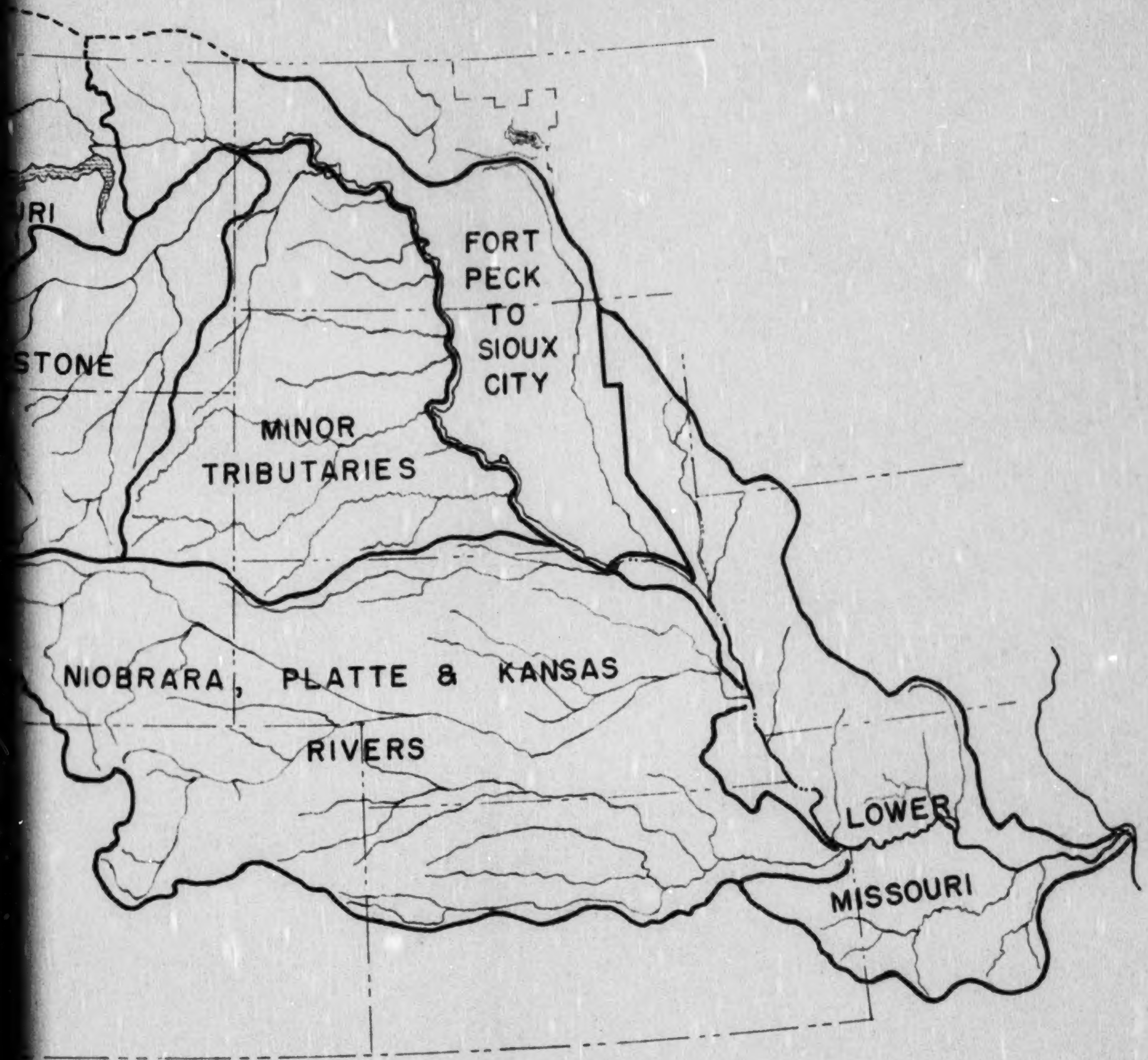
PRINCIPAL SUBDIVISIONS


UPPER MISSOURI
FORT PECK TO SIOUX CITY
YELLOWSTONE
MINOR TRIBUTARIES
NIOBRARA, PLATTE & KANSAS RIVERS

MAP No. 1

MISSOURI RIVER BASIN

PRINCIPAL SUBDIVISIONS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MINOR TRIBUTARIES
NIOBRARA, PLATTE & KANSAS RIVERS
LOWER MISSOURI

MAP No. 1

May 1950

In 1940 the population of the Missouri Basin was about 7,000,000 persons, 55 percent of whom resided in the Lower Missouri Basin, the latter Basin being that area included in Iowa, Missouri, northwestern Kansas, eastern Nebraska, and southeastern South Dakota. Sixty-six percent of the Basin's population reside in urban areas and 34 percent in rural districts.

Source of Pollution in the Missouri River Basin

The Missouri River and its tributary streams receive the polluting effects of sewage either treated or untreated from 905 municipalities, institutions and unincorporated communities where sanitary sewers serve a population of 3,353,871 persons. The municipal sewers also serve a multitude of industrial installations whose wastes usually do not receive preliminary treatment. The total population equivalent of the waste discharged to municipal systems, either treated or untreated, is estimated to be that of 4,673,600 persons. The waste load contributed by 104 industrial installations discharging directly to the stream is estimated to have a population equivalent of 5,221,800 persons. The total waste load, therefore, from both industrial and municipal sources would be equivalent to that produced by 9,895,500 persons. There is an additional but undetermined amount of pollution coming from 465 communities and numerous industries for which data is lacking or insufficient to warrant classification. The full load therefore may be revised upward upon receipt of more information.

Water Use and Adequacy of Water for Indicated Uses

The conservation of the water resources and their proper use is extremely important in the entire Missouri River Basin, and every legitimate usage of water within the basin will be greatly benefited by the Water Resources Development Program now in progress. The water necessary to support the urban population of the basin, for both domestic uses and for sanitation, is extremely valuable. It is estimated that the cost of the water to the consumer amounts to approximately $45,000,000 annually. More than 60 percent of the water used is derived from surface sources. There is no means, at the present time, of estimating the value of this water for either domestic or sanitary needs because of the many intangibles attached to the use of water. Although Water Resources Development Program for the Missouri Basin will be of tremendous value, it will also create problems for many communities. These problems are essentially of three kinds: first, taste and odor problems in the surface water systems are expected to increase; second, a decrease in dilution water resulting from stream regulation thereby causing an unusually high degree of sewage treatment to preclude local nuisances; and third, an increase in mosquito populations sufficient in some instances to adversely affect the health and welfare of the public. The storage of vast amount of water will, unless proper control measures are developed, create many ideal environments for the production of vast numbers of insects capable and known to transmit certain diseases, and otherwise adversely affecting the welfare of those using or residing near hydraulic structures. In view of the many benefits and problems thus created by such a vast development program, it seems essential that the inclusion of all sanitary and public health aspects of water use be of prime importance.

Need for Treatment Works

It is estimated that 270 new treatment works will be needed to supplement those 620 plants now in existence and that 166 of those plants in existence will need improvements in the immediate future. The cost of these immediate needs is estimated to approximate $50,000,000. This cost would be for plants primarily designed to serve municipal sewerage systems. Forty new industrial treatment works are needed and improvements are necessary to 5 plants now in existence. The status of 40 industrial plants is unknown. It is difficult, if not impossible, to estimate the cost of essential industrial treatment works, however, it will probably be in the range of $15,000,000. If appropriate treatment is provided in those 453 municipalities whose status has not yet been determined, it is quite likely that $15,000,000 more will be needed to complete the program. A total expenditure in the general range of $80,000,000 may therefore be required for the abatement of domestic and industrial pollution in the Missouri Basin.

Tables 1 and 2 list data relative to sources and amounts of pollution and treatment needs as indicated by available data for the entire basin.

TABLE 1

MISSOURI BASIN

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	1,370	3,353,871	4,673,648
Industrial Plants b/	104	---	5,221,853 (Est.)
Total	1,474	3,353,871	9,895,501

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the non-similar wastes in terms of a common unit, Population Equivalent.

TABLE 2

MISSOURI BASIN

Sewage and Industrial Waste Treatment Plant Requirements

Source (1)	Total No. (2)	Without Treatment			With Treatment			No Project Req'd (9)	No Data (10)
		No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)		
Municipalities	1,370	283	247	33	622	166	84	375	465
Industrial Plants	104	52	49	7	11	5	4	1	41
Total	1,474	335	296	40	633	171	88	376	506

Conclusions and Recommendations

1. Water use in the Missouri Basin is highly varied and embraces many factors of prime importance to the economy and welfare of the region. Of greatest importance are its uses for domestic and industrial water supplies, and as a vehicle for the removal and ultimate disposal of sewage wastes from communities and industries. Surface waters are of great value for the dilution of sewage wastes, thereby permitting a lesser degree of treatment than would normally be required without use of this natural resource. Other important uses include irrigation, fish and wildlife propagation, livestock watering, hydroelectric power generation, navigation, and to a lesser degree, bathing and recreation.

2. Pollution problems of the Missouri Basin are predominately those of municipal wastes, with relatively few sources of significant industrial wastes from packing and slaughter houses, oil and sugar beet refineries, and diversified manufacturing establishments. Of the great number of municipal waste outlets, a preponderance of communities having a population of less than 50,000 is readily apparent. While the Basin has many and varied industries, for the most part, these establishments discharge trade wastes into municipal sewerage systems. An aspect of the over-all problem which will be of increasing importance is the proper control of increased industrial activities resulting from the land and water resource development program now in progress in the Missouri Basin.

3. Abatement of pollution is an integral and important aspect of any program for increased utilization and development of the water resources of the Basin. Pollution abatement measures have not kept pace with municipal and industrial development, with the result that at many locations water quality has deteriorated sufficiently to adversely affect important water uses. Adequate pollution abatement measures are of special significance as related to the quality of water for fish and wildlife propagation, municipal and industrial water supplies, irrigation, bathing, and recreation. The relationship of water quality to livestock watering, commercial fishing, hydroelectric power, and navigation is important, but of lesser significance.

4. Utilization of surface water for the dilution of treated or partially treated sewage wastes has great economic value to industries and communities in the Basin by providing the maximum use of this important resource. Communities and industries alike have over exploited this resource for this purpose, with the result that streams have been burdened over and above their natural capacity to assimilate pollution, particularly under critical

conditions that exist during periods of low flow in warm weather, and in periods of prolonged ice cover where reaeration is practically precluded.

5. The Congress has stated that primary responsibility for pollution abatement rightfully rests with State Governments and has authorized Federal enforcement action, with the consent of the State, only when State programs break down so as to adversely affect the health, or the welfare of people in another State. It is important to note that in the Missouri Basin, State programs are somewhat ineffective in that several of the States do not have a statutory basis for the development of comprehensive programs as related to all water uses, or for the abatement of pollution even where same is clearly evident.

6. The water resource development program, as now carried on in the Missouri Basin, possessed great potentialities for alleviation of problems of pollution abatement through regulation of stream flows and related measures. Releases for sanitation purposes are quite often reused farther downstream for irrigation, power, navigation, and other uses, and such releases do not therefore represent a consumptive use of water. Benefits are usually additive because of repeated uses for communities farther downstream where large segments of the population are reached. This field of interest is either not within the authorized scope of activities of the Federal Agencies responsible for the planning and construction of water resource development projects, or is of such secondary interest that this utilization of water resource has not generally been recognized in project planning. Accomplishments in this field as noted appear to be principally where use of water for dilution purposes does not represent an actual consumptive use, or where requirements for this purpose are so small that they do not interfere with the primary objectives of the project under consideration. It is further important that project costs for regulating low flows for sanitation purposes be chargeable on a basis comparable to that governing other water uses having sectional or national importance.

7. Problems of water supply and pollution abatement are sufficiently related to the water resource development program and of such importance to merit inclusion in the over-all planning objectives for this activity in the Basin. It should constitute an integral portion of the planning for each individual project.

8. A significant portion of the pollution abatement structures existing in this Basin were installed under the Public Works Programs of the 1930's under the impetus of Federal Grants. There is at this time considerable interest in an accelerated abatement

program, and municipalities and industries are generally aware of project needs. While, as a rule, municipalities are in good financial status, it is clearly apparent that municipalities in this Basin are withholding construction in the hope and belief that Federal assistance for the construction of abatement works will be available within the near future.

9. The Federal Water Pollution Act, as now constituted, implies limited financial assistance for the construction of abatement works. Financial assistance, either in the form of construction grants or measures to insure lower interest rates, would do much to accelerate abatement progress. The value of financial assistance in the construction of abatement works in the Missouri Basin is in all probability enhanced by the great number of relatively small communities where the unit cost of abatement measures are somewhat higher than prevails in larger areas of population.

10. The water resource development program of the Missouri Basin is closely associated with problems of health and welfare as influenced by insect vectors. Control measures as necessary to safeguard health and welfare should be incorporated in project design as an integral portion of over-all planning.

UPPER MISSOURI RIVER SUB-DIVISION

Description of Sub-Division

The Upper Missouri River rises along the eastern slope of the Rocky Mountains, and lies almost wholly within the State of Montana. Principal tributaries are the Jefferson, Madison, Gallatin, Musselshell and Milk Rivers whose flow is derived principally from springs and snow-fed mountain streams. The river, in its upper reaches, is a clear, turbulent stream with an average slope of 4.5 feet per mile. An estimated 5,000,000 acre-feet of water is contributed annually to the main stem of the Missouri River from tributaries in this portion of the Missouri Basin. Climatological characteristics are those of a semi-arid region, with an average rainfall approximating 12 inches, much of which occurs in the form of torrential downpours during the growing season. Temperatures are exceedingly variable, ranging between a low of -52° F. to a high of 110°. The average annual temperature in the vicinity of Yellowstone Park is 32° F. while in the plain region it is 38° F. Humidity is relatively low. Precipitation is primarily influenced by the presence of the Rocky Mountains, which deflect storms blowing from the West Coast. Therefore, most of the rain and snow is of local origin or from storms blowing southward from the Hudson Bay Region of Canada.

Characteristic of the region is the extremely varied topography. Long stretches of the river are surrounded by rugged mountains ranging up to 13,000 feet. The lower end of the Basin has an elevation of approximately 3,300 feet at the valley bottom. The river flows out of the mountainous area at a point about 30 miles above Great Falls, Montana, enters a glaciated and unglaciated region known as the Missouri Plateau, and continues through that plateau for some 1,500 miles.

The quality of the surface waters is generally good and is suitable for irrigation and municipal usage. Surface water is used extensively since ground resources are usually quite inaccessible and limited in supply. In the plains section of the Basin it is necessary to drill usually to depths of 300 feet or more to obtain potable water in satisfactory quantities for domestic uses. It is quite common for farmers to haul water great distances and store it in cisterns for future domestic use. There are, however, a number of spectacular springs in the mountainous sections of the Basin. As far as is known there have been no aquifers in which ground water levels have been depressed by excessive pumpage.

The Upper Basin is quite rich in mineral resources, such as gold, silver, lead, zinc, copper, coal, oil, and gas. There are also large deposits of coal and oil shales which remain to be developed. Limited deposits of radioactive material also exist in this region.

The mountainous section is quite heavily forested with native stands of spruce and pine, while the plains and plateau areas are generally untenable for vegetation growths except that of the sage brush variety. Mountain forests have a decided effect on the surface runoff pattern. After the spring flows from melting snows the minor tributary streams in the plains area dry up and no further water is generally available. In the mountainous sections, flows are more or less uniform throughout the winter and spring, continuing through the months of June and July. They taper off thereafter, but in most instances continue to flow throughout the year.

Agricultural pursuits form the major occupation of the Sub-division's population. Land uses in descending order are grazing lands, arable dry land farming and irrigated farming, forestation, and Indian Reservations. According to the 1940 census, agriculture supported 162,557 persons, or approximately 65 percent of the total population of the Sub-division.

The principal industries of the Upper Missouri River Sub-division are mining, smelting, oil production and refining, food processing, and resort and tourist operations. In recent years there has been a marked increase in industrial operations throughout the Sub-division, and the urban populations have increased rapidly while the rural population has decreased slightly.

The Sub-division is served by three major transcontinental railroad systems and a well developed system of highways. The natural beauty of the mountainous regions lying within the Upper Basin, and primarily within the National Park Systems, are responsible for a large tourist and resort industry which constitutes a sizable portion of the Sub-division's income. Water resources of the upper river division have been primarily responsible for its development. The rapid flowing river has provided power for industry. The volume of water available has made irrigation feasible along considerable lengths of the river and the clear, clean waters have provided a readily accessible supply of water for municipal and industrial uses. The many mountain streams have provided excellent fishing, which has added materially to the other attractions of the region and bring an increasing volume of tourist trade each year. It may be expected that industry will continue to expand, particularly new industries such as the production of liquid fuels from the large deposits of lignite and coal. Feasibility of this development is enhanced by the presence of large volumes of water necessary to the processing of these fuels.

Early settlers of the Basin were primarily interested in agriculture. The raising of cattle on the enormous ranches of Montana was, for many years, a principal occupation. There followed a period during which dry land farming became a large operation. While numerous drought periods drove many of the farmers from the region, those remaining became increasingly interested in irrigation, and the area of irrigated land has continued to increase. Mining and oil industries also are important and for some time have steadily increased in economic importance. Major trade and industrial centers are Great Falls, Helena, Bozeman, Havre, Cut Bank and Glasgow, Montana. Great Falls is the largest city in the Sub-division and is the center of the copper mining and smelting industry for the entire region.

In general the residents are progressive and are interested and eager to develop the resources of the Basin to their fullest extent. Water resources have received early attention. Development of power resources at Great Falls, near Great Falls, Montana, and the construction of Fort Peck Reservoir are great strides in a development program. Numerous other important projects are under active consideration. Comprehensive water resource development must recognize the needs of urban and rural districts. Since the waters of the region are responsible for a considerable income from the tourist trade, its uses for the continued propagation of fish and other wildlife are also extremely important. Water for the irrigation of truck gardens must be relatively free from the effects of pollution. Pollution abatement therefore is an important aspect and an integral part of the water resources development program for the Upper Missouri River Sub-division.

Sources of Pollution

There are 34 municipalities or institutions contributing domestic waste, either treated or untreated, to streams of the Upper Missouri River Sub-division. Map No. 2 indicates sources of pollution with data pertinent thereto. An estimated 120,000 persons residing in the urban areas are provided sewer service. Numerous food processing and other industrial operations located in these municipalities add a considerable amount of waste to the sewerage systems, but the actual population equivalent of these industrial wastes is unknown. It is estimated, however, that the municipal sewerage systems discharge waste to the streams, including that of industrial operations located within the city or town, equivalent to a population of 96,000 persons. There are 7 large industrial operations in the Sub-division which are not serviced by municipal sewerage systems and which waste directly into the streams. The U. & I. Sugar Refinery at Chinook, Montana, discharges an estimated population equivalent of 33,000 persons. The other industries, which are composed of mining operations, oil refining and oil production, contribute large amounts of silt and toxic substances, besides organic wastes for which the population equivalent is unknown. The total amount of wastes contributed to streams is estimated to be equivalent to a population of 221,243.

The effect of pollution from domestic sources in this area is usually local in nature, however that from industrial sources, particularly those wastes which contain toxic material, affect fish propagation and recreational uses of streams for considerable distances. It has been reported that waste oil discharged from the railroad and oil refining operations to the Upper Missouri River near Great Falls, Montana is so excessive that it accumulates on the hydro-power generating turbine wheels of the Montana Power Company sufficiently to reduce the production capacity of the turbines and necessitating their withdrawal from service at frequent intervals for the purpose of removing the accumulations of grease and oil. There have been frequent complaints from fishermen that the flesh of fish taken from streams below large municipal or industrial waste sewer lines is so badly tainted that it is unfit for human food.

Water Use and Adequacy of Water for Indicated Uses

Map No. 3 illustrates existing water uses in the Upper Missouri Sub-division. Approximately 122,000 persons in 13 municipalities obtain their water for domestic uses from the surface waters. It is estimated that 30 million gallons of water is provided daily for municipal and industrial uses in these communities. This water costs the consumer about $3,200,000 annually. Its value to the consumer would be difficult to ascertain; however it would greatly exceed the cost. The volume of water for municipal use, not including sanitation, is of considerable importance as compared to the current demand for irrigation purposes. The former, for the most part, is returned to the streams substantially undiminished in quantity but polluted by domestic and industrial wastes. Since large volumes of dilution water are necessary for disposal of sewage wastes without treatment, it seems reasonable to assume that the volume of flow for sanitation needs is comparable with that required for irrigation unless pollution is controlled in some other manner. Abatement of pollution will therefore result in increased volumes of water being made available for irrigation developments.

In most instances, the distances between the sources of pollution do provide an opportunity for the waters to substantially absorb the polluting material before being used again. These blocks of polluted stretches of the streams do adversely affect the propagation of fish life and the recreational uses of the stream. The conservation of fish in this area is very important since the income from the tourist trade forms a substantial portion of the entire income of the Basin. The practice of irrigating land with waters contaminated by domestic waste is held by most public health authorities to be a hazardous practice, particularly where such waters are used on truck gardens or fruits or vegetables to be consumed raw.

Under present conditions of flow in the streams there has been sufficient water to meet the requirements of both domestic and sanitary uses; for power development and for irrigation purposes. Under critical conditions, such as in ice covered streams or in streams having very low flow, nuisance conditions caused by excessive pollutional loads have occurred.

The development plan should be of benefit for sanitation, irrigation, power, and fish and wildlife conservation if minimum flows in the streams are maintained at a sufficiently high level to provide the necessary dilution water. Establishment of minimum flow figures must be preceded by further investigation. Pollution abatement is of paramount importance to minimize the adverse effects of impaired water quality on various water uses, and permit the release of large quantities of water for beneficial use of higher priority than sewage dilution. The clarification of the waters in the storage reservoirs may produce taste and odors due to algae growths, thus increasing the problems of domestic water treatment for the municipalities.

Need for Treatment Works

The treatment works needs for the Upper Missouri River Subdivision are illustrated in Tables No. 3 and No. 4. It will be noted of the 55 municipalities 10 are known to be without treatment facilities, 6 communities not now having treatment need such facilities badly, and the status of 21 other communities is unknown. Twenty-four of the 55 communities now have some form of sewage treatment; 5 of these plants need to be reconditioned or rebuilt, the status of 7 of the treatment plants is unknown; and 11 communities are in need of new sewage treatment works or major improvements to existing facilities.

There are 7 industrial plants discharging waste directly into the stream. Six of these need treatment works, and the status of the seventh plant is unknown.

It is estimated that construction of primary treatment facilities for the 11 projects needed immediately would cost $1,300,000. If, however, treatment facilities are provided sufficient to remove 70 to 90 percent of all pollution from the waste before it is discharged to the stream, the estimated cost would be $3,600,000. This latter figure includes the cost of secondary treatment works for those communities for which there is no data available. The number of inhabitants in these latter communities are small in number and would not affect the total figure by more than 5 percent. It is quite probable that the number of projects needing immediate attention will be revised upward pending the receipt of information concerning the status of those communities now listed under the category of status unknown.

TABLE 3

UPPER MISSOURI BASIN

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	55	120,000	96,000
Industrial Plants b/	7	---	*125,000 (Est.)
Total	62	120,000	221,000

* Toxic wastes.

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

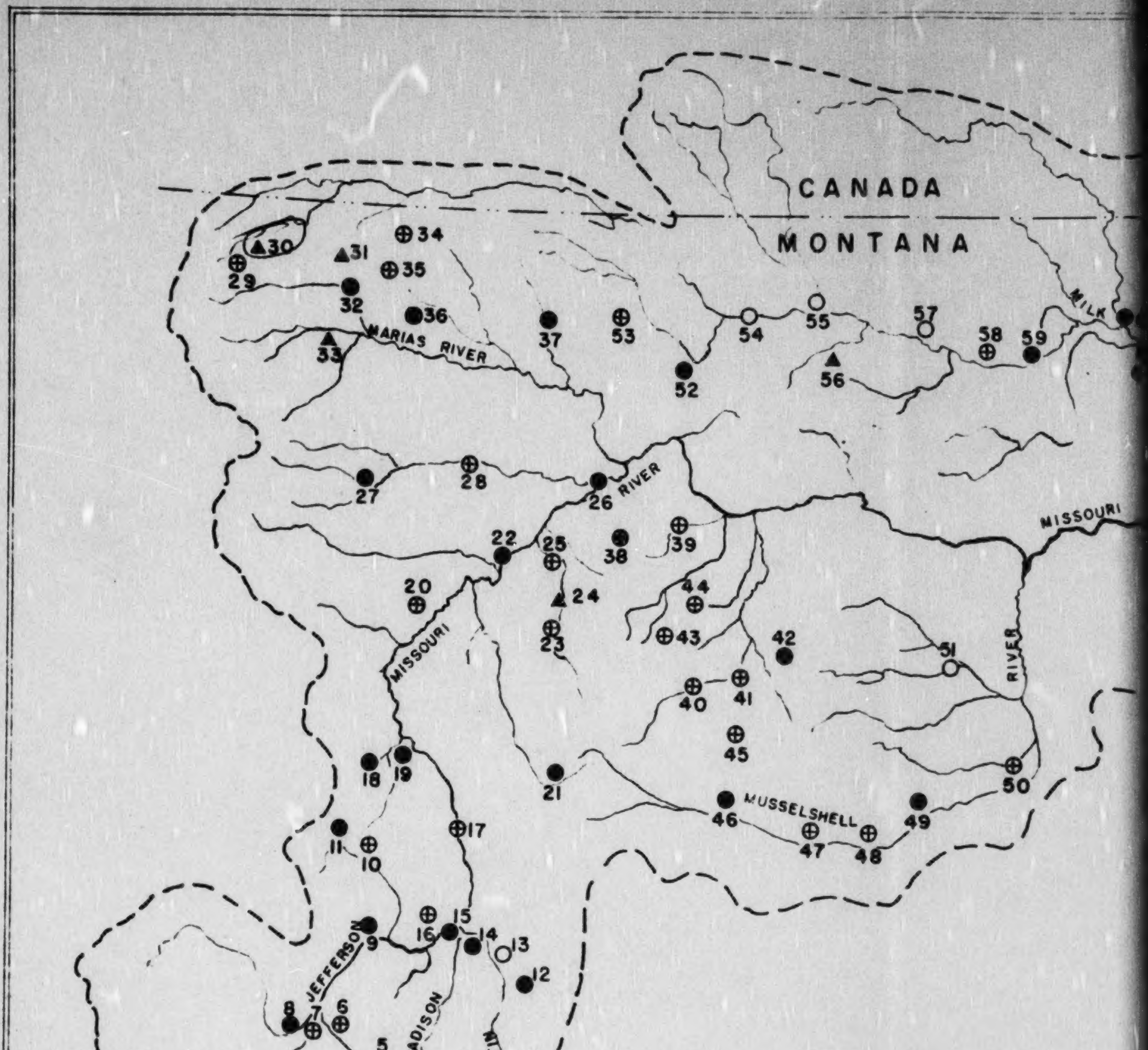
d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the nonsimilar wastes in terms of a common unit, Population Equivalent.

TABLE 4

UPPER MISSOURI BASIN

Sewage and Industrial Waste Treatment Plant Requirements

		Without Treatment			With Treatment			No	
Source (1)	Total No. (2)	No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)	Project Req'd (9)	No Data (10)
Municipalities	55	10	6	3	24	5	7	13	21
Industrial Plants	7	7	6	1					
Total	62	17	12	4	24	5	7	13	21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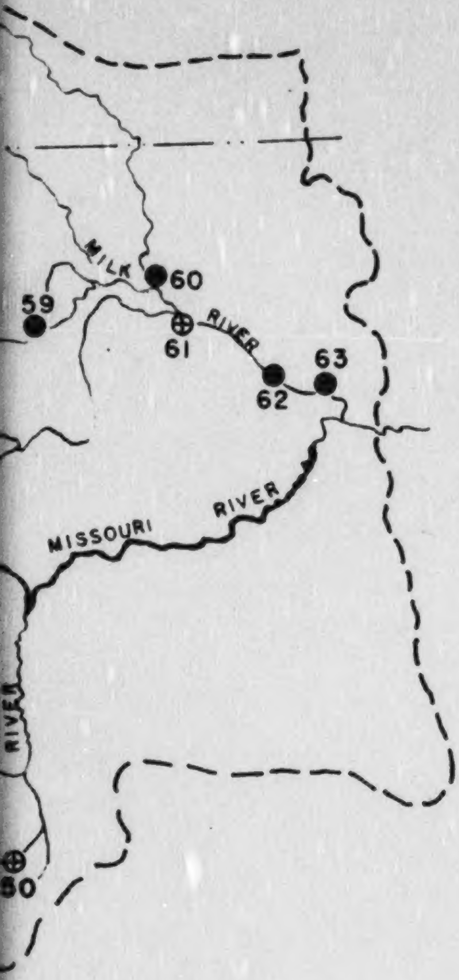


UPPER MISSOURI BASIN
SOURCES OF POLLUTION

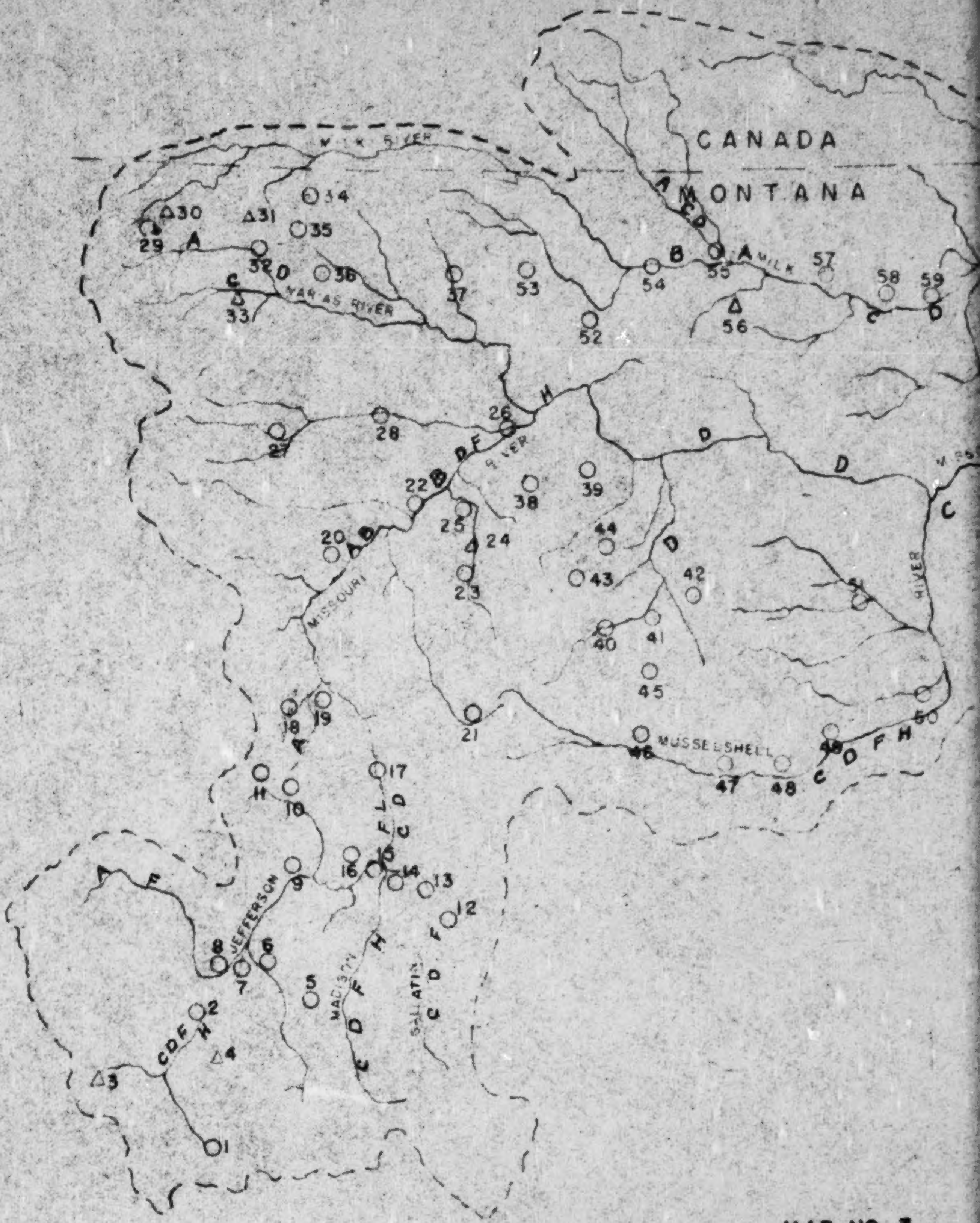
NO.	NAME	NO.	NAME
1	LIMA	34	SUNBURST
2	DILLON	35	KEVIN
3	MINING	36	SHELBY
4	SILVER STAR MINES	37	CHESTER
5	VIRGINIA CITY	38	WINIFRED
6	SHERIDAN	39	GERALDINE
7	TWIN BRIDGES	40	HOBSON
8	STATE ORPHANS' HOME	41	MOORE
9	WHITEHALL	42	LEWISTOWN
10	BOULDER	43	STANFORD
11	STATE TRAINING SCHOOL	44	DENTON
12	BOZEMAN	45	JUDITH GAP
13	BELGRADE	46	HARLOWTON
14	MANHATTAN	47	RYEGATE
15	THREE FORKS	48	LAVINA
16	TRIDENT	49	ROUNDUP
17	TOWNSEND	50	MELSTONE
18	HELENA	51	WINNETT
19	EAST HELENA	52	BIG SANDY
20	CASCADE	53	HINGHAM
21	WHITE SULPHUR SPRINGS	54	HAVRE
22	GREAT FALLS	55	CHINOOK
23	NEIHART	56	U.B.I. SUGAR CO.
24	LEAD & SILVER MINES	57	HARLEM
25	BELT	58	DODSON
26	FORT BENTON	59	MALTA
27	CHOTEAU	60	SACO
28	DUTTON	61	HINSDALE
29	BROWNING	62	GLASGOW
30	RAILROAD SHOPS	63	NASHUA
31	OIL-REFINERY		
32	CUT BANK		
33	OIL-FIELDS		

LEGEND

SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	⟁	UNKNOWN STATUS

MAP NO. 2

MAY 1950


CANADA
MONTANA
MILK RIVER
MILK
MARIAS RIVER
RIVER
MISSOURI
RIVER
MUSSELSHELL
JEFFERSON
MADISON
GALLATIN
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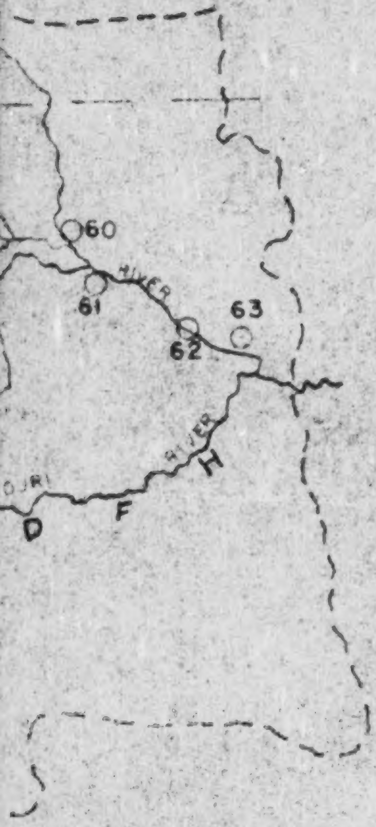
MAP NO. 3



UPPER MISSOURI BASIN

EXISTING WATER USES

SOURCES OF POLLUTION

NO	NAME	NO.	NAME
1	LIMA	34	SUNBURST
2	DILLON	35	KEVIN
3	MINING	36	SHELBY
4	SILVER STAR MINES	37	CHESTER
5	VIRGINIA CITY	38	WINIFRED
6	SHERIDAN	39	GERALDINE
7	TWIN BRIDGES	40	HOBSON
8	STATE ORPHANS' HOME	41	MOORE
9	WHITEHALL	42	LEWISTOWN
10	BOULDER	43	STANFORD
11	STATE TRAINING SCHOOL	44	DENTON
12	BOZEMAN	45	JUDITH GAP
13	BELGRADE	46	HARLOWTON
14	MANHATTAN	47	RYEGATE
15	THREE FORKS	48	LAVINA
16	TRIDENT	49	ROUNDUP
17	TOWNSEND	50	MELSTONE
18	HELENA	51	WINNETT
19	EAST HELENA	52	BIG SAND
20	CASCADE	53	HINGHAM
21	WHITE SULPHUR SPRINGS	54	HAVRE
22	GREAT FALLS	55	CHINOOK
23	NEIHART	56	U.B.I. SUGAR CO
24	LEAD & SILVER MINES	57	HARLEM
25	BELT	58	DODSON
26	FORT BENTON	59	MALTA
27	CHOTEAU	60	SACO
28	DUTTON	61	HINSDALE
29	BROWNING	62	GLASGOW
30	RAILROAD SHOPS	63	NASHUA
31	OIL REFINERY		
32	CUT BANK		
33	OIL-FIELDS		

LEGEND

A- DOMESTIC WATER SUPPLY
B- INDUSTRIAL WATER SUPPLY
C-LIVESTOCK WATER SUPPLY
D-IRRIGATION WATER SUPPLY
E-COMMERCIAL FISHING
F-GAME FISHING

G- SHELLFISH
H- WILDLIFE
I - BATHING WATER
J- OTHER RECREATION
K- NAVIGATION
L-OTHER LEGITIMATE USES

MAY 1950

THE YELLOWSTONE RIVER SUB-DIVISION

Description of Sub-Division

The Yellowstone River Sub-division is located in central Wyoming and southeastern Montana and occupies a small portion of extreme western North Dakota. The Basin has a total length of about 440 miles and is about 320 miles wide at its point of maximum width. The total drainage area of approximately 70,400 square miles is divided about evenly between Montana and Wyoming, with less than 1,000 square miles located in North Dakota. This Subdivision contributes approximately 6,800,000 acre-feet of water annually to the Missouri River. The headwaters of the river are formed in Yellowstone National Park. The length of the Yellowstone River is 670 miles, and the slope averages 35 feet per mile from the headwaters to Livingston, Montana, and 7.2 feet per mile from Livingston to the mouth. Lake Yellowstone is approximately 142,000 acres in area and provides a considerable regulatory effect on the flows throughout the Yellowstone River system. Immediately below the lake, Yellowstone River traverses 21 miles of deep steep-sided canyons and falls approximately 1,500 feet in the first 6 miles. Most of the water originates from melting snows in the high mountain ranges and from numerous springs issuing from the canyon walls. The period of maximum flow of the Yellowstone and its tributaries occurs during the months of April, May, June, and the early part of July; thereafter the flows diminish rapidly. The mean annual flow at the point of confluence with the Missouri River is 11,000 second feet. The lowest recorded flow for a period of one day at this point was 1,400 second feet. Serious floods occur in this system, usually caused by backwater from ice jams.

The water in the upper reaches of the Yellowstone and its tributaries is clear and free from extensive mineralization and is readily usable for the propagation of fish life, recreational purposes, irrigation, and municipal water supplies. However, as the stream progresses, great quantities of silt and considerable amounts of mineral matter are acquired. It is estimated that 23 percent of all silt carried by the Missouri River past Kansas City, Missouri, is contributed by the Yellowstone system. The waters of the Yellowstone are sufficiently mineralized in its lower reaches to necessitate proper drainage of irrigated land in order that unduly large concentrations of salt are not built up in the soils. The silt carried by the stream poses a problem for both irrigation projects and users of the water for domestic purposes. The fine silt clogs the irrigation ditches and decreases the permeability of the soils upon which the silt-carrying waters are placed.

Municipalities using the water must construct extensive treatment works to remove the silt. Few if any fish are able to survive in the lower reaches and little use is made of the lower river for recreational purposes. The major tributaries of the Yellowstone are the Big Horn, Clark, Tongue, and Powder Rivers.

The topography of the Yellowstone Sub-division is generally characterized by foothills and rugged mountain ranges of the Rocky Mountains. Eastern and northerly portions of the Sub-division extend into the Missouri plateau section of the Great Plains. Mesas are found interspersed among the benchlands of this portion of the Sub-division. There are numerous lakes located in mountainous regions, of which Yellowstone Lake is the largest. Soils in this area, like those located in the northern part of the Missouri Basin, are generally of two kinds, those formed by overflowing of streams and those formed in place by natural disintegration of rock formations.

The extreme elevations found in this Sub-division contribute largely to the extremes of temperature; the mean annual temperature in Yellowstone Park is 32°F. while that at Bridger, Montana, is 46.8°. In the plains region, a maximum recorded temperature of 117° has been reported at Glendive, Montana, and a minimum of -65°. has been reported from Miles City, Montana. Rainfall over the entire Basin is rather sparse, averaging approximately 12 inches per year. Much of this precipitation may occur in the form of short violent rainstorms, accompanied by very rapid runoffs and considerable erosion of the upland soils. The humidity of the region is relatively low. It is necessary to irrigate most crops in order to assure a harvest. There has been only limited development of ground water sources as there is usually enough only for domestic and stock water use. In most instances, ground water can be readily found in the alluvial fills along the streams. Some deep wells have been drilled but few have produced appreciable volumes of water. Water produced is usually soft but contains a high sodium concentration and therefore is generally unusable except for stock watering. There are a few flowing wells in the extreme lower reaches of the Sub-division. In the mountainous region, particularly in Yellowstone Park, great numbers of hot springs produce a considerable volume of water. There are also numerous other springs feeding tributaries of the Yellowstone. The largest of these springs, producing approximately 20 million gallons of hot water daily, is located at Thermopolis, Wyoming. The difficulty with which ground waters are obtained, together with their usually high mineral content, has caused most municipal and industrial users of water to obtain and treat surface waters. Only the very small communities and rural areas are therefore dependent on ground water supplies. There are no areas within the Yellowstone Sub-division where the ground waters have been unduly depressed by excessive pumpage.

A great variety of minerals, including coal, gypsum, bentonite, sulphur, phosphate, gold, chromite, copper, tungsten, silver, iron, zinc, lead, molybdenum, nickel, and platinum, are to be found in the mountainous section of the Yellowstone Sub-division. The production and processing of gas and oil is a major industry. There are also great deposits of oil shale from which liquid fuels may be extracted. The extensive deposits of phosphate rock may become the principal future source of phosphate fertilizer for the great middle western agriculture region. Coal deposits are widespread and are mined with comparative ease. There are great areas of natural forests in the mountainous sections of the Yellowstone Basin, which for the most part are now national forest reserves. These extensive forests provide a considerable regulatory effect on runoff. Without this regulation, flows of the streams would undoubtedly vary much more than they do. The forests also lend an attractive addition to the natural beauty of the rugged high mountains and the phenomena of nature concentrated in Yellowstone Park, which now forms America's greatest vacation playground.

The Yellowstone Sub-division supported a population of 212,000 people in 1940. About one-third of the population was engaged in farming or livestock raising and the remainder in industry and service operations. Agriculture pursuits are more valuable than any other single operation. In irrigated areas, very intensive farming is practiced. Livestock feed and sugar beets are the principal farm produce. Sugar refineries are located throughout the region. It will be noted that both agricultural and industrial operations rely greatly on the water resources; first as a source of water for irrigation purposes; and second, as a source of water for industrial processing; and to remove the wastes produced.

Further development of water resources will probably not affect the economy of the Sub-division as much as it may affect the economy of the Missouri River Basin as a whole. It will, however, greatly aid in desilting the streams and will in all probability maintain a higher flow during periods of normal minimums, a fact which will assist both municipal and industrial water users in obtaining an adequate supply. Desilting the water and controlling the pollution from both industrial and municipal sources will enhance the propagation of fish life and will add to the attractiveness of the region to tourists. Catering to the tourist trade is already one of the principal sources of revenue. The presence of large volumes of water resulting from the completion of the proposed water resources development program may greatly influence the development of liquid fuel production from coal and oil shales which are found in great abundance throughout the mountainous and foothill regions. Waste products from these operations must be carefully controlled to prevent the deterioration of water quality for other uses in the downstream reaches of the river. There have been instances in the past where the uncontrolled discharge of domestic and industrial wastes to the Yellowstone River has greatly restricted the downstream use of water for irrigation and domestic purposes. The diversified usage to which the waters of the Yellowstone Sub-division are put indicates that a very careful evaluation of the actual and potential sources of pollution must be included as a part of the over-all water resources development program.

Sources of Pollution

Sources of pollution and pertinent information are shown on Map No. 4. There are 46 municipalities located in this Sub-division contributing either raw or treated sewage from an estimated 110,000 persons served by sanitary sewer systems. There are 16 major industrial plants in this Sub-division having an estimated industrial waste population equivalent of 1,175,000. At least 6 of these industries operate seasonally and discharge wastes in the fall of the year when the stream flow is at a minimum. Treated and raw wastes from domestic and industrial sources discharged into the river and its tributaries is estimated to be equivalent to a population of 1,285,000 persons. This figure will probably be revised upward upon receipt of information concerning industrial wastes which are yet to be determined.

In addition to the population equivalent of these wastes, a considerable amount of silt and toxic material is discharged to the streams from mining operations, sugar factories, oil production and refining. The contamination of the streams with toxic materials may be serious at times since such contaminants are not readily removed by natural purification processes occurring in the streams. Silt is removed by sedimentation in the larger storage reservoirs, and by other methods at the water purification plants. This silt represents a loss to the area in which it originated, and decreases the life of the storage reservoirs and increases the cost of treatment at water purification plants. The greatest source of pollution in the Sub-division is in the vicinity of Billings, Montana, from 3 oil refineries, a meat packing plant, a brewery, a cannery, and oil wastes from the railroad roundhouse at Laurel, Montana. There are several other communities where local pollution conditions have developed from putrefaction of domestic and industrial wastes in water courses immediately below the points of discharge. In most instances in the Sub-division natural purification in the stream enables it to recover from the effects of these wastes before the water is again used. This pollution may, however, form an effective barrier in the stream thereby preventing fish from migrating upstream or downstream.

Water Uses and Adequacy of Water for Those Uses

Map No. 5 illustrates existing water uses in the Yellowstone Sub-division. The economy of the region has centered around the Yellowstone River and its tributaries. Intensive irrigation has been practiced in some portions of the Sub-division since the early 1880's. Some of the first projects of the U. S. Bureau of Reclamation are to be found in this Sub-division. Water for municipal use throughout the Sub-division comes largely from the Yellowstone River and its tributaries. Many municipalities in the area must obtain their water from the river, since much of the ground water is highly mineralized. It is estimated that domestic water consumption from both surface and ground water sources is approximately 28.3 million gallons per day or 31,700 acre-feet annually. About 89.4 percent of this volume of water is taken from surface streams and the remainder from ground water sources. Water taken from streams by municipalities is of course returned in substantially the same quantity but in the form of sewage. It is estimated that water supplies through municipal systems costs the immediate consumer $2,580,000 annually. Its value to consumers is much greater.

Several hydroelectric plants are located on the upper reaches of the stream. Plans are now under way for the development of additional hydroelectric power to be used for pumping irrigation water.

The headwaters of all of the streams provide excellent game fishing. The recreational aspects of the streams have been highly developed in certain areas of the headwaters, particularly in Yellowstone Park; other sections have depreciated in value because of municipal and industrial pollution. Mining interests polluting the stream have been of considerable concern to fish, wildlife, and conservation interests throughout the Sub-division. The actual monetary depreciation to the stream is difficult to ascertain, but nevertheless it is great.

Need for Treatment Works

Summary of the sewage treatment needs and of existing works is shown in Tables No. 5 and No. 6. Eleven new plants are needed, and of the 23 plants now in existence, four should be rebuilt or improved as required. The status of sewage treatment at 19 other cities or towns is unknown. Seven of the 16 or more industrial plants discharging waste directly to the streams are known to need treatment, but available data are insufficient to indicate whether or not additional plants may also be needed. It is estimated that the cost of new plants and improvements needed immediately by municipalities would approximate $1,425,000. In some locations industry has recognized their responsibility in protecting the streams by installing waste treatment facilities. It is to be anticipated that other industries will follow the same footsteps.

TABLE 5

YELLOWSTONE SUB-DIVISION

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	65	128,965	110,000
Industrial Plants b/	16	---	*1,175,000 (Est.)
Total	81	128,965	1,285,000

* Silt and toxic materials also discharged.

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

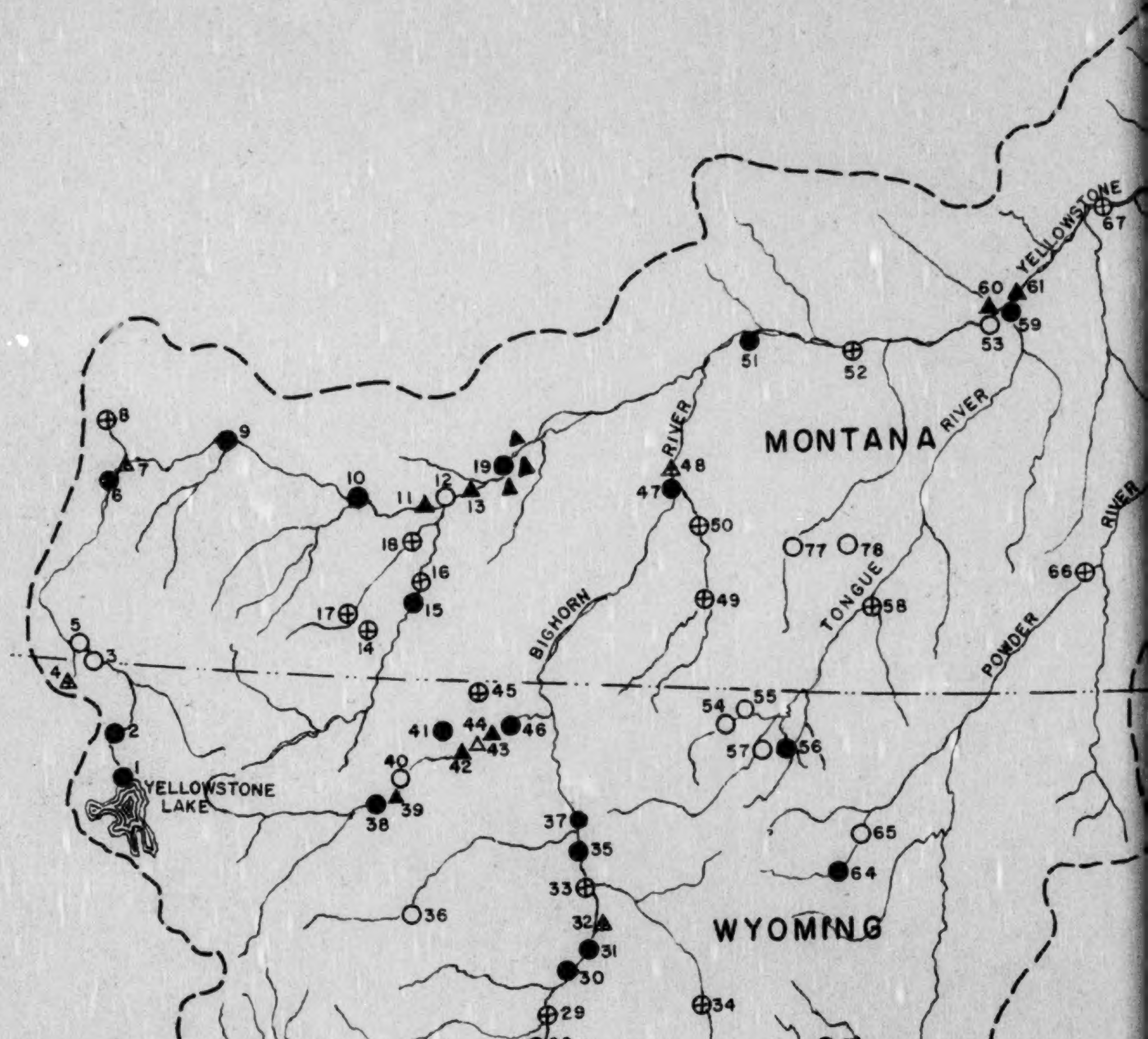
d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the nonsimilar wastes in terms of a common unit, Population Equivalent.

TABLE 6

YELLOWSTONE SUB-DIVISION

Sewage and Industrial Waste Treatment Plant Requirements

Source (1)	Total No. (2)	Without Treatment			With Treatment			No Project Req'd (9)	No Data (10)
		No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)		
Municipalities	65	23	11	10	23	4	10	11	19
Industrial Plants	16	9	7	2	7	3	2	1	1
Total	81	32	18	12	30	7	12	12	20


MONTANA
WYOMING
YELLOWSTONE LAKE
YELLOWSTONE
BIGHORN
RIVER
TONGUE
RIVER
POWDER
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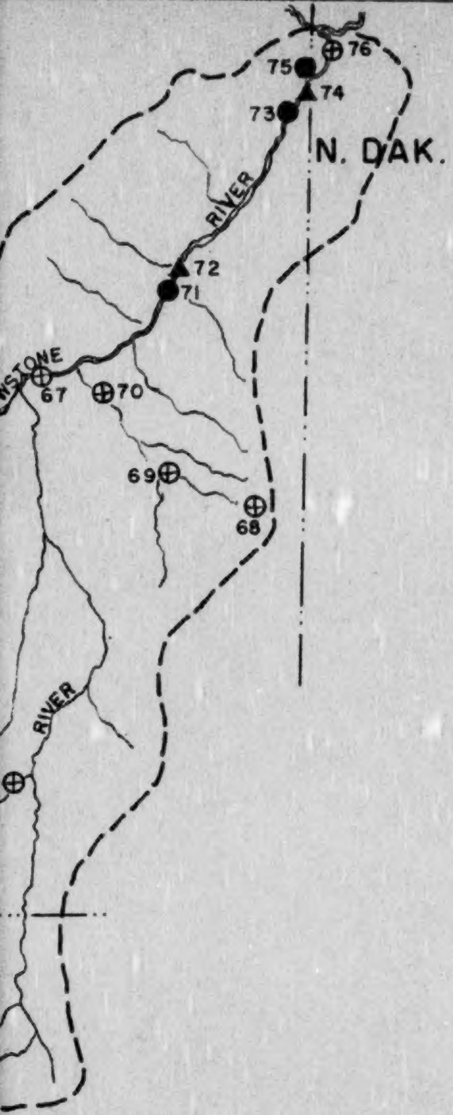
MAP NO.4



YELLOWSTONE BASIN

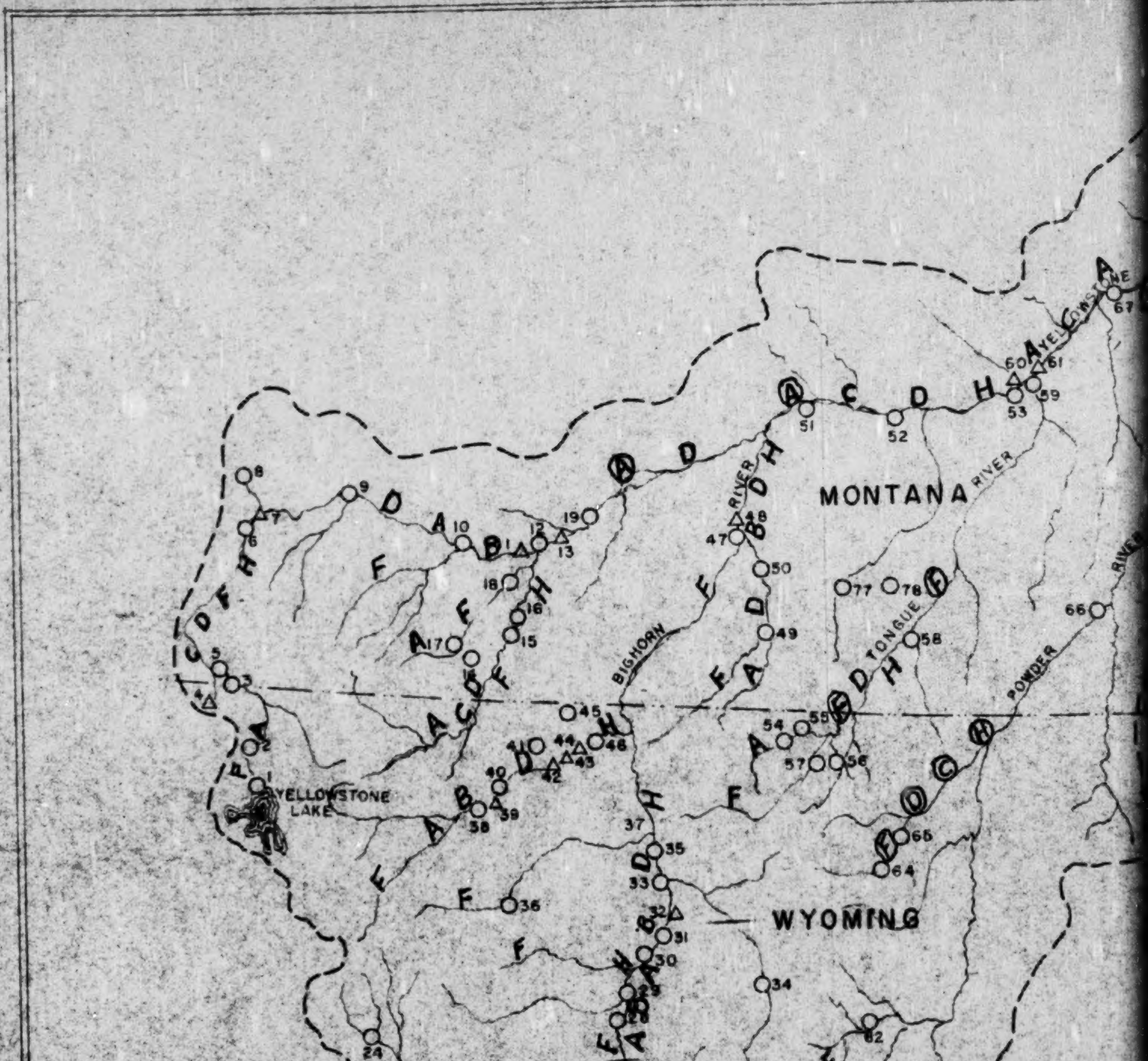
SOURCES OF POLLUTION

NO.	NAME	NO.	NAME
1	LAKE	41	POWELL
2	CANYON	42	POWELL OIL REFINERY
3	MAMMOTH	43	OHIO OIL REFINERY
4	MINING WASTE	44	HUSKY REFINING CO.
5	GARDINER	45	COWLEY
6	LIVINGSTONE	46	LOVELL
7	R.R. SHOP WASTE	47	HARDIN
8	CLYDE PARK	48	SUGAR PLANT
9	BIG TIMBER	49	LODGEGRASS
10	COLUMBUS	50	CROW AGENCY
11	CO-OP REFINERY	51	HYSHAM
12	LAUREL	52	FORSYTH
13	R.R. SHOP WASTE	53	FORT KEOUGH
14	BEARCREEK	54	DAYTON
15	BRIDGER	55	RANCHESTER
16	FROMBERG	56	SHERIDAN
17	RED LODGE	57	V. A. HOSPITAL
18	JOLIET	58	BIRNEY
19	BILLINGS	59	MILES CITY
20	LANDER	60	MEAT RENDERING
21	HUDSON	61	R. R. SHOPS
22	SHOSHONE INDIAN RES.	62	KAYCEE
23	WASHAKIE	63	MIDWEST
24	DUBOIS	64	BUFFALO
25	RIVERTON	65	CLEARMONT
26	PAVILLION	66	BROADUS
27	SHOSHONI	67	TERRY
28	THERMOPOLIS	68	BAKER
29	KIRBY	69	PLEVNA
30	WYO. BOYS' INSTITUTE	70	ISMAY
31	WORLAND	71	GLENDIVE
32	HOLLY SUGAR REFINERY	72	R.R. SHOPS
33	MANDERSON	73	SIDNEY
34	TENSLEEP	74	HOLLY SUGAR CO.
35	BASIN	75	FAIRVIEW
36	MEETEETSE	76	ALEXANDER
37	GREYBULL	77	BUSBY
38	CODY	78	LAME DEER
39	HUSKY REFINING CO.		
40	HEART MOUNTAIN		

LEGEND

SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	◬	UNKNOWN STATUS

MAY 1950


MONTANA
WYOMING
YELLOWSTONE LAKE
BIGHORN
RIVER
TONGUE
RIVER
POWDER
RIVER
YELLOWSTONE
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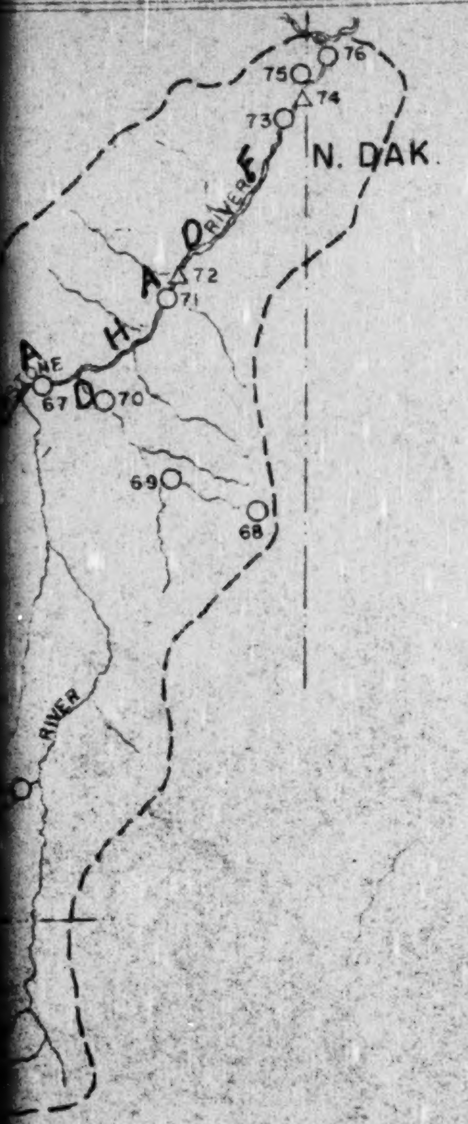


YELLOWSTONE BASIN

EXISTING WATER USES

SOURCES OF POLLUTION

NO.	NAME	NO.	NAME
1	LAKE	41	POWELL
2	CANYON	42	POWELL OIL REFINERY
3	MAMMOTH	43	OHIO OIL REFINERY
4	MINING WASTE	44	HUSKY REFINING CO.
5	GARDINER	45	COWLEY
6	LIVINGSTONE	46	LOVELL
7	R.R. SHOP WASTE	47	HARDIN
8	CLYDE PARK	48	SUGAR PLANT
9	BIG TIMBER	49	LODGEGRASS
10	COLUMBUS	50	CROW AGENCY
11	CO-OP REFINERY	51	HYSHAM
12	LAUREL	52	FORSYTH
13	R.R. SHOP WASTE	53	FORT KEOUGH
14	BEARCREEK	54	DAYTON
15	BRIDGER	55	RANCHESTER
16	FROMBERG	56	SHERIDAN
17	RED LODGE	57	V. A. HOSPITAL
18	JOLIET	58	BIRNEY
19	BILLINGS	59	MILES CITY
20	LANDER	60	MEAT RENDERING
21	HUDSON	61	R.R. SHOPS
22	SHOSHONE INDIAN RES.	62	KAYCEE
23	WASHAKIE	63	MIDWEST
24	DUBOIS	64	BUFFALO
25	RIVERTON	65	CLEARMONT
26	PAVILLION	66	BROADUS
27	SHOSHONI	67	TERRY
28	THERMOPOLIS	68	BAKER
29	KIRBY	69	PLEVNA
30	WYO. BOYS' INSTITUTE	70	ISMAY
31	WORLAND	71	GLENDIVE
32	HOLLY SUGAR REFINERY	72	R.R. SHOPS
33	MANDERSON	73	SIDNEY
34	TENSLEEP	74	HOLLY SUGAR CO.
35	BASIN	75	FAIRVIEW
36	MEETEETSE	76	ALEXANDER
37	GREYBULL	77	BUSBY
38	CODY	78	LAME DEER
39	HUSKY REFINING CO.		
40	HEART MOUNTAIN		

LEGEND

A- DOMESTIC WATER SUPPLY
B- INDUSTRIAL WATER SUPPLY
C- LIVESTOCK WATER SUPPLY
D- IRRIGATION WATER SUPPLY
E- COMMERCIAL FISHING
F- GAME FISHING
G- SHELLFISH
H- WILDLIFE
I- BATHING WATER
J- OTHER RECREATION
K- NAVIGATION
L- OTHER LEGITIMATE USES

MAP NO. 5

MAY 1950

MINOR TRIBUTARIES SUB-DIVISION

Description of Sub-Division

This Sub-division, containing 10 important minor tributaries, lies in the center of the entire Missouri Basin area and includes the western half of South Dakota, the southwestern quarter of North Dakota, a small portion of southeastern Montana, and a portion of northeastern Wyoming. River Basins included in this Sub-division are: the Little Missouri, Heart, Knife, Cannonball, Grand, Moreau, Cheyenne, Bad, and White.

These tributaries contribute about 1½ million acre-feet of water annually to the main stem of the Missouri River. The flow characteristics of these minor tributaries are very much the same. They are likely to be flooded in the months of March, April, May, and June due to melting snow and rains; thereafter the flow dwindles rapidly until the streams are often dry in their upper reaches in September and October. As an example of the erratic nature of flows in these tributaries, it has been noted that as much water has been discharged by one of the streams in one month as may flow in the same stream during an entire year during a period of lesser or minimum precipitation. The minor tributaries are usually heavily ladened with silt and some contain a considerable quantity of sodium and magnesium salts.

The streams average from 200 to 400 miles in length with the Cheyenne River system the longest and contributing the largest volume of water to the Missouri River. The river gradients are all quite similar and range from 4 to 6 feet per mile. The elevation of the headwaters is very near the 3,000 foot mark. Belle Fourche River, tributary of the Cheyenne River, is the longest and the largest tributary to any stream in the Sub-division.

The climatological characteristics of the Minor Tributary Sub-division might be summarized as those of a semiarid region, having rainfall varying between 10 and 15 inches per year with minimum temperatures of -42° F., maximum temperatures of 112° F., and a mean annual temperature of 45° F. Relative humidity is low with evaporation accounting for much of the precipitation. It has been characterized "the north side of the Great Plains dust bowl." The Black Hills uplift located in the southwestern portion of the division is, however, an exception of this statement. The average rainfall in the Black Hills exceeds 18 inches and the annual mean temperature is 46.9°. This region has a decided regulatory influence on the discharge of the Cheyenne River inasmuch as much of the flow in the river originates within the Black Hills.

The topography of the Minor Tributaries Sub-division may be described as that of a plains area. Streams have cut deep-sided valleys through most of the region, and wind and water have eroded sections of the plateau into grotesque formations commonly known as "Badlands". These formations may be found in southwestern North Dakota and southwestern Central South Dakota. For the most part the area is barren of vegetation with the exception of short grasses. In contrast to these plains regions, the Black Hills uplift rises to an elevation of over 6,000 feet and is heavily covered with coniferous timber.

Ground water in the region is exceedingly difficult to obtain, and that which is available often has such a high sodium and magnesium content that it is of no value for either domestic or irrigation purposes. There are, however, numerous springs within the Black Hills region which supply large volumes of good water. In the eastern portion of the Sub-division ground waters may be obtained from depths below 1,000 feet in fairly large quantities, but highly mineralized. The only known place in the Sub-division where the ground water table has been depressed by excessive pumpage is at Rapid City, South Dakota. It has been necessary to construct a low head dam across Rapid Creek for the purpose of raising the water table in the aquifer supplying water for municipal use. The generally poor quality of the ground water has so limited its use that no attempt has been made to develop large supplies from this source.

Mineral deposits are located principally in the Black Hills although oil is found in considerable quantity in eastern Wyoming. Large deposits of lignite coal lie in northwestern South Dakota and southwestern North Dakota. Gold, silver, zinc, lead, and good grades of building stone are mined in considerable quantities within the Black Hills. The mining of gold deposits in the Black Hills area was primarily responsible for the initial development of other resources in the area. Forestry is a major industry in and along the western slope of the Black Hills, and a thriving lumber business has developed. The remainder of the Sub-division--the plains area--is almost treeless, except for indigenous growths along the border of the streams. The forests have served to regulate to a substantial degree the runoff occurring within the Black Hills area and, in addition, they have made the natural beauty of the region more attractive. Numerous parks are located throughout the Black Hills section of South Dakota and eastern Wyoming.

The local economy is based largely upon agriculture, principally the production of wheat in the tillable dry-land areas; however ranching is by far the largest of the land-use operations. Climatic conditions are such that surety of a harvest is by no means certain. Irrigation within the Sub-division is limited, due primarily to lack of water to supply the needs, and secondly, the limited area in which suitable soils are found upon which irrigation may be successfully practiced. Industrial development consisting of mining and smelting, oil production and refining, and food processing, have been limited almost entirely to the Black Hills region and eastern Wyoming. Gold mining and smelting operations in the Black Hills are among the largest in the United States. Oil production and refining is centered in eastern Wyoming. Several flour mills are also located in eastern Wyoming and the Black Hills region. In recent years the tourist trade in the Black Hills area has become a major source of revenue.

Further development and conservation of the water resources will provide water for: (1) additional tillable land suitable and available for irrigation, (2) municipal and industrial uses, and (3) fish and wildlife propagation and other recreational purposes. Water resources development, however, will probably have little effect on industrial expansion because of the lack of markets and limited transportation facilities within the Sub-division. A further development of the water resources therefore will be of most value to agriculture, to municipal domestic water users, fish and wildlife propagation, and recreation.

The population of the region was greatest shortly after the turn of the century and has dwindled sharply since then. The 1940 census indicates the population of the Sub-division totaled 262,000 persons with approximately 55 percent of them residing in urban areas and 45 percent in rural districts. There was a decided reduction in the rural population following the drought periods between 1930 and 1940. The urban population showed a slight gain during the same period while sharp gains have been registered during the period 1940 to 1950. It is expected that with the development of water resources for irrigation purposes that there will bea movement of population towards the farm districts; however population of this area is not likely to increase materially because of the climatical and topographical features and the limited natural resources.

The industrial and trade centers of the Sub-division are located principally at Rapid City, Lead, Deadwood, Belle Fourche, and Hot Springs, in South Dakota; Dickinson, North Dakota; Newcastle and Gillette, Wyoming. Rapid City, the largest city, has almost doubled its size in the last decade. It is the trading center for a vast area and has recently become the tourist center for the entire Black Hills region. Gold mining and smelting operations are centered at Lead and Deadwood, South Dakota. Dickinson, North Dakota, is the trading center for southwest North Dakota. When water resources near the cities of Rapid City and Dickinson have been developed as contemplated by the Bureau of Reclamation, the municipal water supplies of these communities will be greatly augmented. The presence of irrigated lands immediately below the larger cities make it imperative that pollution control be considered in the over-all development program. Municipal water supplies and recreational uses of the water also lend emphasis to a pollution control program.

Sources of Pollution

There are 52 municipalities or institutions contributing either untreated or treated wastes to the streams and waterways of the Minor Tributaries Sub-division. Identification and location of sources of pollution are given in Map No. 6. It is estimated that 102,000 persons of the 107,000 residing in the cities and towns (having a population greater than 250) are served by sanitary sewerage systems. There are also numerous food processing and other industrial operations located in these communities which are contributing waste, the strength and volume of which are unknown, to the sewer systems. It is estimated, however, that treated and untreated wastes from municipal sewerage systems would be that equivalent to 57,390 persons, indicating an average removal of 44 percent of the strength of the wastes prior to discharge to streams. Further investigation will undoubtedly reveal that the estimate of pollution discharged is low, and that revisions upward will be necessary. Seven industries in the fields of oil production and refining, mining, smelting of lead, gold, silver, and zinc; and the refining of beet sugar are known to be discharging waste directly to the streams. The first two types of industrial operations contribute considerable amounts of toxic material in addition to organic pollution, and the population equivalent of wastes from these plants is unknown. Data on discharges to streams by sugar refining operations indicate that these wastes have a population equivalent approximating 125,000.

The population equivalent from both domestic and industrial sources discharged to the waterways of the Minor Tributaries Sub-division is estimated as 185,000. The majority of municipal wastes are from cities of less than 5,000 population. The largest city within the Sub-division is Rapid City, South Dakota, where an estimated 20,000 persons contribute sewage to the municipal sewerage system. Fifty-five percent of the municipalities having a population of more than 250 persons have sewage treatment works of varying degrees of efficiency. This percentage may be greater when 20 of the municipalities whose status is unknown are properly classified.

Water Use and Adequacy of Water for Indicated Uses

Map No. 7 indicates important water uses in the Sub-division. The water supply problem for all indicated uses is an acute one, as large volumes of water from either ground or surface sources are not available. Only 11 of 72 communities studies, representing a population of 23,000, or about one-fifth of the urban population of the Sub-division, obtain all or part of their municipal water supplies from surface sources. It is estimated that all municipal water supply sources produce 15 million gallons of water daily for domestic use, and that this water costs the consumer $2,000,000 annually. Since four-fifths of the urban population of the Basin is supplied with water from underground sources, approximately 12 million gallons of waste water each day would be added to the surface waterways of the Sub-division, thus increasing the annual discharges by some 14,000 acre-feet. In areas such as those existing in this Sub-division where water is of great value, considerable benefits may be attached to the recovery of this waste water for irrigation and recreational uses by means of sewage treatment. The rather high percentage of municipalities treating sewage has been brought about by insufficient water in receiving streams to provide a proper degree of dilution, and if treatment was not practiced serious nuisances would have resulted. There are many instances where sufficient dilution water in streams would have effected a considerable savings in construction costs of present sewage treatment works. It is believed that if minimum flow can be provided from projects now under construction in this region, the total water use program will be greatly benefited. Water resources development, on the other hand, will necessitate greater control of pollution for many communities in order to safeguard water quality for such uses as public water supplies, recreation purposes, fish and wildlife propagation, and irrigation. Water resources development will increase problems associated with vectors of disease. Public health authorities generally agree that the increase in the numbers of insects, primarily mosquitoes, due to development of storage reservoirs and irrigation practices may result in increased incidence of insect-borne diseases which heretofore have existed in this area in endemic form. It is believed that the development of the water resources in this region where the scarcity of water has always been a retarding factor will be of special benefit to municipalities for water supply and sanitation. It is also believed that these needs are of sufficient economic and social value to the urban dwellers to rate on a par with power and irrigation values. Since there probably never will be enough water to satisfy all demands it is essential that all needs are carefully weighed before allotments of water are made for any specific purpose.

Need for Treatment Works

The status of the existing sewage treatment works and the needs for new treatment works are illustrated in Tables 7 and 8. There are 38 municipalities having sewage treatment facilities, 14 of which need immediate improvements and the status of 4 of these plants is unknown. Fourteen cities of over 250 inhabitants are without sewage treatment works and it is considered necessary that all 14 provide some degree of treatment. Six of the 7 industrial operations do not at the present time have adequate treatment facilities; suitable disposal units should be installed. The seventh industry, a sugar refining plant, has primary treatment in effect which should be augmented with a higher degree of treatment. Insufficient data for 20 municipalities makes it impossible to properly classify them. It is estimated that $1,500,000 would construct the 14 new plants needed and the improvements to 14 other plants, and that an expenditure of $2,750,000 would provide treatment with an efficiency between 60 and 80 percent for all municipalities and industrial installations within the Sub-division in those cities and industries studied. This latter figure also includes the cost of secondary treatment for all those towns for which no data is now available.

TABLE 7

MINOR TRIBUTARIES SUB-DIVISION

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	72	102,020	59,743
Industrial Plants b/	7	—	*125,000 (Est.)
Total	79	102,020	184,743

* Much waste consists of toxic material.

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

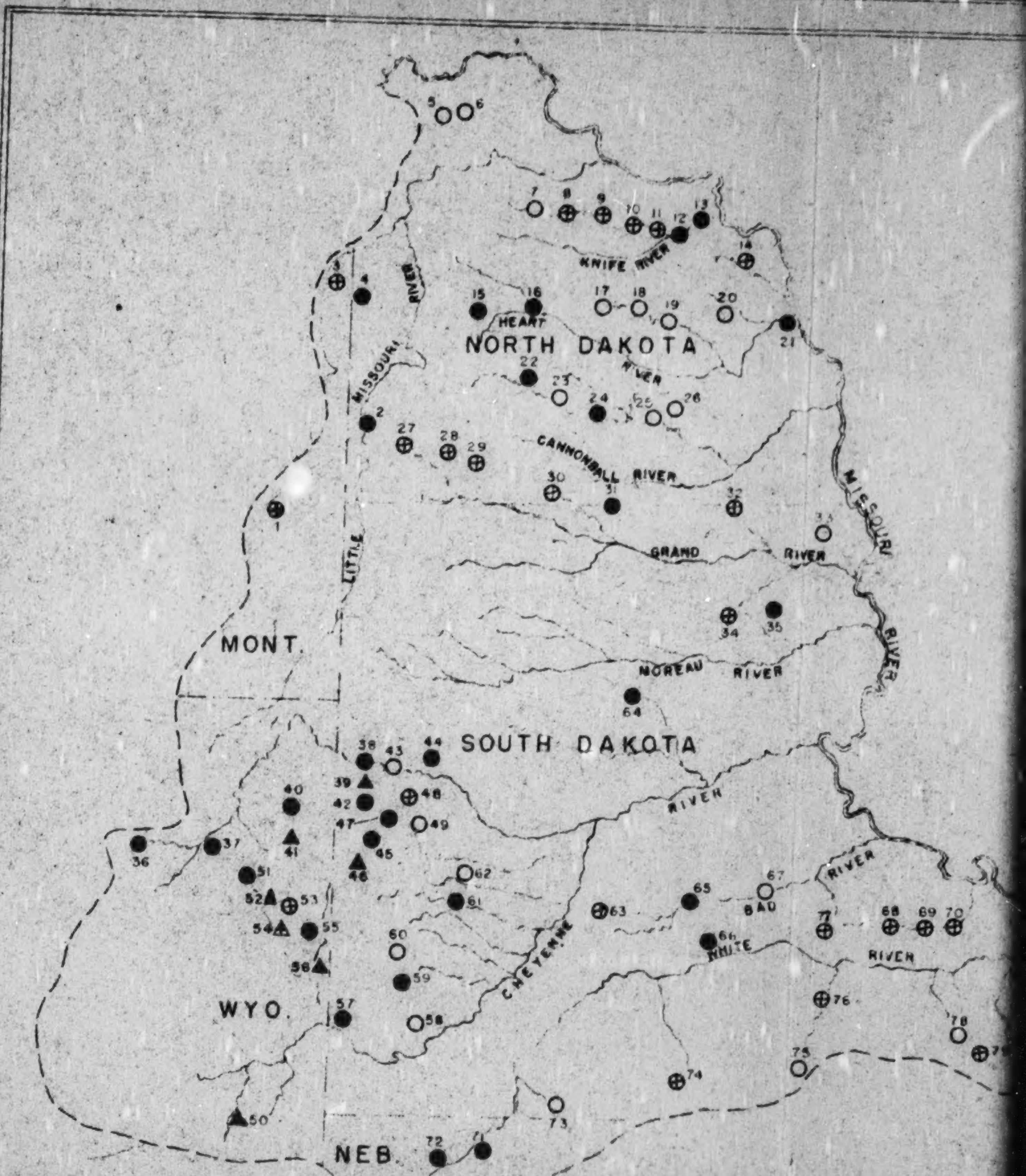
d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the non-similar wastes in terms of a common unit, Population Equivalent.

TABLE 8

MINOR TRIBUTARIES SUB-DIVISION

Sewage and Industrial Waste Treatment Plant Requirements

Source (1)	Total No. (2)	Without Treatment			With Treatment			No Project Req'd (9)	No Data (10)
		No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)		
Municipalities	72	14	14	0	38	14	4	20	20
Industrial Plants	7	6	6		1	1			
Total	79	20	20	0	39	15	4	20	20



5
6
7
8
9
10
11
12
13
14
KNIFE RIVER
3
4
LITTLE MISSOURI RIVER
15
16
HEART RIVER
17
18
19
20
21
NORTH DAKOTA
22
23
24
25
26
2
27
28
29
CANNONBALL RIVER
30
31
32
33
MISSOURI RIVER
1
GRAND RIVER
34
35
MONT.
MOREAU RIVER
64
SOUTH DAKOTA
38
43
44
39
40
42
48
47
49
RIVER
36
37
41
45
46
51
62
52
53
61
63
65
67
BAD RIVER
54
55
60
66
WHITE RIVER
77
68
69
70
56
59
CHEYENNE
WYO.
57
58
76
78
75
74
73
50
NEB.
72
71

MINOR TRIBUTARIES

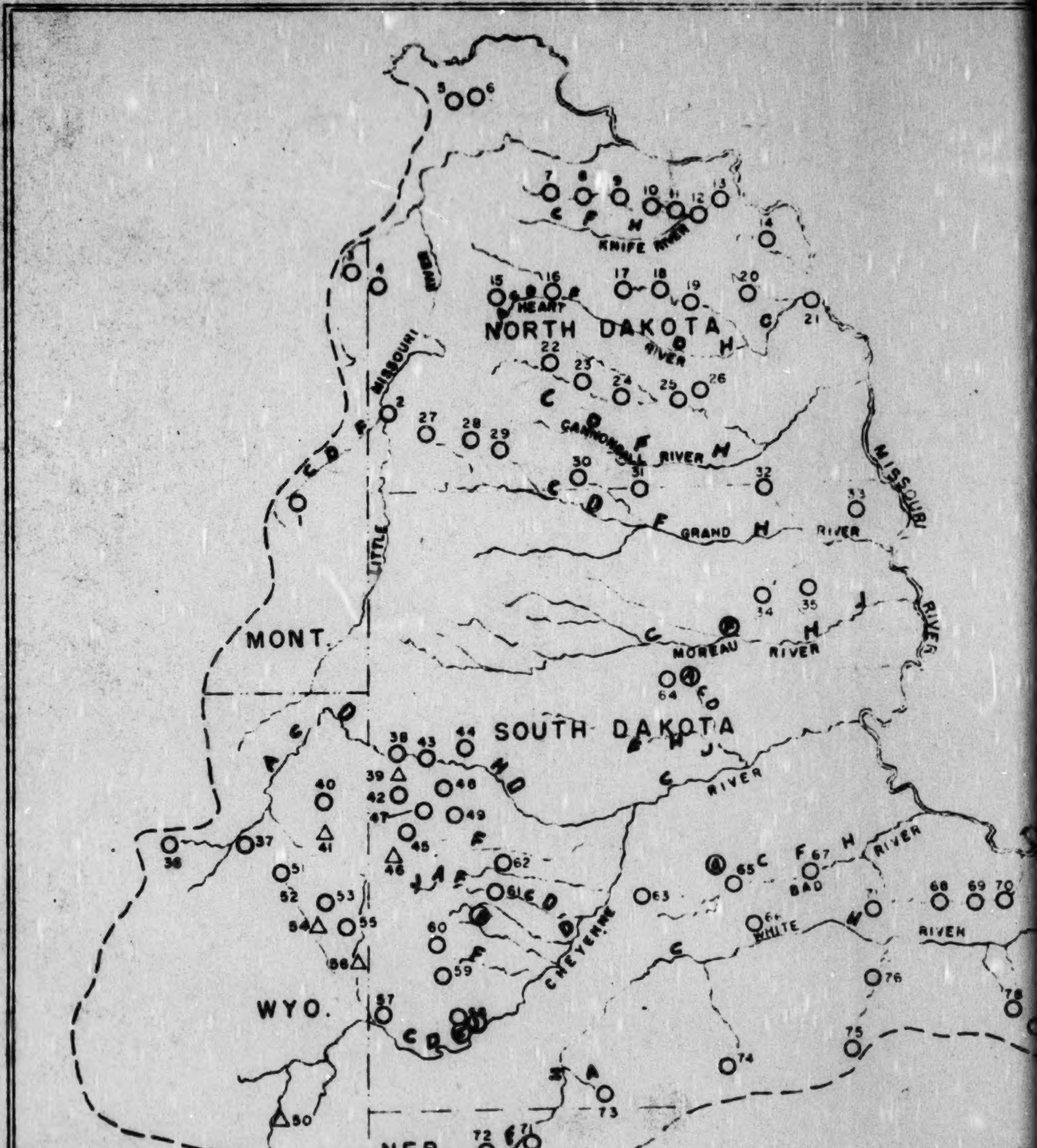
SOURCES OF POLLUTION

NO.	NAME	NO.	NAME
1.	Ekalaka, Mont.	41.	Oil Refinery
2.	Marmouth, N.D.	42.	Spearfish, S.D.
3.	Wibaux, Mont.	43.	Nisland, S.D.
4.	Beach, N.D.	44.	Newell, S.D.
5.	Arnegard, N.D.	45.	Lead, S.D.
6.	Watford City, N.D.	46.	Gold Mines
7.	Killdeer, N.D.	47.	Deadwood, S.D.
8.	Dunn Center, N.D.	48.	Whitewood, S.D.
9.	Halliday, N.D.	49.	Sturgis, S.D.
10.	Golden Valley, N.D.	50.	Oil Fields
11.	Zap, N.D.	51.	Upton, Wyo.
12.	Beulah, N.D.	52.	Oil Refinery
13.	Hazen, N.D.	53.	Osage, Wyo.
14.	Center, N.D.	54.	Oil Refinery
15.	Belfield, N.D.	55.	Newcastle, Wyo.
16.	Dickinson, N.D.	56.	Oil Refineries
17.	Richardton, N.D.	57.	Edgemont, S.D.
18.	Hebron, N.D.	58.	Hot Springs, S.D.
19.	Glen Ullin, N.D.	59.	Sanator, S.D.
20.	New Salem, N.D.	60.	Custer, S.D.
21.	Mandan, N.D.	61.	Rapid City, S.D.
22.	New England, N.D.	62.	Rapid City, S.D.(A.B.)
23.	Regent, N.D.	63.	Wall, S.D.
24.	Mott, N.D.	64.	Faith, S.D.
25.	New Leipzig, N.D.	65.	Phillip, S.D.
26.	Elgin, N.D.	66.	Kadoka, S.D.
27.	Rhome, N.D.	67.	Midland, S.D.
28.	Bowman, N.D.	68.	Vivian, S.D.
29.	Scranton, N.D.	69.	Presho, S.D.
30.	Hettinger, N.D.	70.	Kennebec, S.D.
31.	Lemmon, S.D.	71.	Chadron, Nebr.
32.	McIntosh, S.D.	72.	Crawford, Nebr.
33.	McLaughlin, S.D.	73.	Pine Ridge, S.D.
34.	Isabel, S.D.	74.	Martin, S.D.
35.	Timber Lake, S.D.	75.	Rosebud, S.D.
36.	Gillette, Wyo.	76.	White River, S.D.
37.	Moorcroft, Wyo.	77.	Murdo, S.D.
38.	Belle Fourche, S.D.	78.	Winner, S.D.
39.	U. & I. Sugar Refinery	79.	Colome City, S.D.
40.	Sundance, Wyo.		

LEGEND

SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	◬	UNKNOWN STATUS

MAP NO. 6 MAY 1950


NORTH DAKOTA
SOUTH DAKOTA
MONT.
WYO.
NEB.
KNIFE RIVER
HEART RIVER
CANNONBALL RIVER
GRAND RIVER
MOREAU RIVER
CHEYENNE RIVER
WHITE RIVER
BAD RIVER
MISSOURI RIVER
LITTLE MISSOURI
C F H
C D F H
C D H
A C D
A E F
C D
A C

MINOR TRIBUTARIES

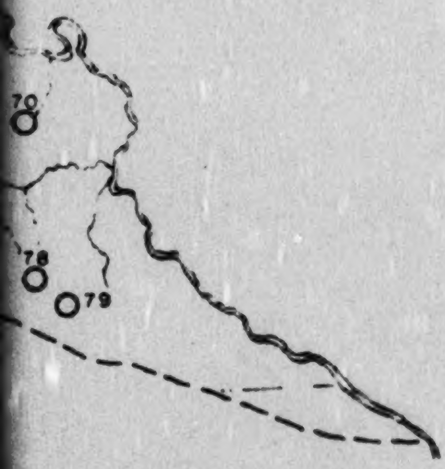
EXISTING WATER USES

SOURCES OF POLLUTION

NO	NAME	NO.	NAME
1.	Ekalaka, Mont.	41.	Oil Refinery
2.	Marmouth, N.D.	42.	Spearfish, S.D.
3.	Wibaux, Mont.	43.	Nisland, S.D.
4.	Beach, N.D.	44.	Newell, S.D.
5.	Arnegard, N.D.	45.	Lead, S.D.
6.	Watford City, N.D.	46.	Gold Mines
7.	Killdeer, N.D.	47.	Deadwood, S.D.
8.	Dunn Center, N.D.	48.	Whitewood, S.D.
9.	Halliday, N.D.	49.	Sturgis, S.D.
10.	Golden Valley, N.D.	50.	Oil Fields
11.	Zap, N.D.	51.	Upton, Wyo.
12.	Beulah, N.D.	52.	Oil Refinery
13.	Hazen, N.D.	53.	Osage, Wyo.
14.	Center, N.D.	54.	Oil Refinery
15.	Belfield, N.D.	55.	Newcastle, Wyo.
16.	Dickinson, N.D.	56.	Oil Refineries
17.	Richardton, N.D.	57.	Edgemont, S.D.
18.	Hebron, N.D.	58.	Hot Springs, S.D.
19.	Glen Ullin, N.D.	59.	Sanator, S.D.
20.	New Salem, N.D.	60.	Custer, S.D.
21.	Mandan, N.D.	61.	Rapid City, S.D.
22.	New England, N.D.	62.	Rapid City, S.D.(A.B.)
23.	Regent, N.D.	63.	Wall, S.D.
24.	Mott, N.D.	64.	Faith, S.D.
25.	New Leipzig, N.D.	65.	Phillip, S.D.
26.	Elgin, N.D.	66.	Kadoka, S.D.
27.	Rhome, N.D.	67.	Midland, S.D.
28.	Bowman, N.D.	68.	Vivian, S.D.
29.	Scranton, N.D.	69.	Presho, S.D.
30.	Hettinger, N.D.	70.	Kennebec, S.D.
31.	Lemmon, S.D.	71.	Chadron, Nebr.
32.	McIntosh, S.D.	72.	Crawford, Nebr.
33.	McLaughlin, S.D.	73.	Pine Ridge, S.D.
34.	Isabel, S.D.	74.	Martin, S.D.
35.	Timber Lake, S.D.	75.	Rosebud, S.D.
36.	Gillette, Wyo.	76.	White River, S.D.
37.	Moorcroft, Wyo.	77.	Murdo, S.D.
38.	Belle Fourche, S.D.	78.	Winner, S.D.
39.	U. & I. Sugar Refinery	79.	Colome City, S.D.
40.	Sundance, Wyo.		

LEGEND

A- DOMESTIC WATER SUPPLY
B- INDUSTRIAL WATER SUPPLY
C-LIVESTOCK WATER SUPPLY
D-IRRIGATION WATER SUPPLY
E-COMMERCIAL FISHING
F-GAME FISHING
G- SHELLFISH
H- WILDLIFE
I - BATHING WATER
J - OTHER RECREATION
K- NAVIGATION
L-OTHER LEGITIMATE USES



MAP NO.7 MAY 1950

NIOBRARA, PLATTE AND KANSAS SUB-DIVISION

Description of Sub-Division

The Niobrara, Platte, and Kansas River Sub-division of the Missouri Basin contains streams which drain the entire State of Nebraska, the southern half of Wyoming, the northern half of Colorado and the northern half of Kansas. These streams and their tributaries contribute each year about 11 million acre-feet of water to the main stem of the Missouri River.

The Niobrara River rises in the high plains region of southeastern Wyoming and flows across the northern part of Nebraska and joins the Missouri River above Yankton, South Dakota. The River is slightly more than 400 miles in length and has an average stream gradient of nine feet per mile. The peculiar geologic formations through which the Niobrara River flows cause the River to have an unusually uniform flow. The low monthly mean flow that may be expected once in ten years near the mouth of the stream is 600 c.f.s. The River carries some silt but is not considered a heavy contributor of suspended matter. The water is excellent chemically and is readily suitable for irrigation and municipal water uses.

The headwaters of the Platte River originate high in the Rocky Mountains at an elevation of over 13,000 feet in the north central section of Colorado. The North Platte drains a large portion of southeastern Wyoming and the South Platte drains the northeastern quarter of Colorado. They join to form the main stem of the Platte River near North Platte, Nebraska, which flows eastward to its confluence with the Missouri River at a point approximately thirty miles south of Omaha, Nebraska. The principal tributaries of the Platte River are the North Platte, South Platte, Loup, and Elkhorn Rivers. The Platte Basin is slightly more than 800 miles in length and contains approximately 90,000 square miles. The flow of the stream is fairly constant near its headwaters, but as it is subjected, downstream, to the effects of weather, the geology of the region, and particularly water usage, an extremely variable flow in the lower reaches of the main stem is created. The mean monthly low flow that may be expected to occur once in 10 years at the mouth is 800 c.f.s.

The headwaters of the Kansas River rise in eastern Colorado in the high plains region and flow across northwestern Kansas and southwestern Nebraska to form the main stem of the Kansas River near Junction City, Kansas. The main stem of the river is approximately 175 miles long and has an average gradient of 3/10 feet per mile. This Basin is about 61,000 square miles in area. The Kansas River, like the Platte, is subjected to the semi-arid conditions of the area but does not have the regulating effect of runoff from the high mountain regions and consequently the streams of this Basin are more variable in flow than those of the Platte Basin. The low monthly mean flow expected once in 10 years at the mouth of the Kansas River is 650 c.f.s. The principal tributaries of the Kansas River are the Republican, Solomon, Saline, Smoky Hill, and Blue Rivers. The chemical characteristics of the Republican and Blue Rivers are such that the water is readily usable for irrigation and municipal uses. The chloride concentration of the Saline and Smoky Hill Rivers makes those waters undesirable for certain domestic uses. The great salt deposits underlying central Kansas are the principal source of the high sodium chloride in these streams, although brine from oil field developments may also contribute to the salt content.

The climatological characteristics of the Sub-division are those of a semi-arid climate from the western bounds to roughly the 98th meridian and those of a sub-humid climate eastward to the Missouri River. The mean temperature is 50° F. with recorded variations between -38° and 116°. Rainfall varies from 18 inches annually in the high plains region to 24 inches in the eastern section. Storms bearing rain or snow may enter the Sub-division either from the north or south, and then travel eastward. These storms are usually quite wide-spread with precipitation occurring over extensive areas. The area within the States of Colorado, Kansas, and southwestern Nebraska are subjected to rather frequent and severe droughts.

The mountainous regions of the western section, the sandhills of the northern portion of the Sub-division, and the plains of the remaining area, indicate the types of topography. The rugged mountain regions of Colorado and Wyoming with elevations ranging up to 13,000 feet typify topography there. The Sand Hill region formed by windblown deposits of sand over ancient igneous rock formation includes most of the northern section of Nebraska. The remaining portion of the Sub-division comes within the classification of the plains region. The valleys are broad and level. Adjacent lands however are usually of a rolling to hilly terrain. The soils along the streams are of alluvial origin while those in most of the upland regions were formed in place by the disintegration of the residual rock. Soils in the eastern portion of the Sub-division are the result of deposits of fine, windblown particles, commonly known as loess.

Ground water is generally available and has been developed for extensive use in a few places. The water is usually hard and highly mineralized but is generally suited for municipal and domestic use and irrigation. Ground water is used extensively for irrigation in the Platte Valley of central Nebraska; near Fort Morgan, Colorado in the South Platte Valley; and along Lodgepole Creek in southeastern Wyoming. Excessive pumpage of ground waters have occurred in the central Nebraska region, resulting in lowering the water table, which in turn has increased the mineral content of the waters. The municipal water supply of Lincoln, Nebraska has been seriously affected by a lowered water table.

The surface water resources of this area, particularly those of the Platte System, have been developed to a higher degree than any other section within the Missouri Basin; however the supply has not been sufficient in many instances to meet the demand. Denver, Colorado derives most of its water supply from the South Platte River, and shortage of water constitutes a serious problem for the city. It would be virtually impossible for the City of Denver to grow either in population or in industrial importance without an increased water supply.

Most of the mineral wealth in this Sub-division consists of coal, iron, gold, silver, lead, and oil and gas, found in the mountain and high plain regions. Little or no minerals with the exception of oil are to be found in Nebraska. Natural deposits of salt as well as oil, gas, and coal, are found in Kansas. Forests of a minor nature are to be found in the mountainous section of Colorado and Wyoming. Belts of trees have been planted across central Nebraska as an adjunct to soil erosion and water conservation methods inaugurated by the State and Federal Departments of Agriculture. The effects of these conservation measures have not yet been ascertained.

The population of the Sub-division was 2,220,000 in 1940. Of this number more than 1,400,000 persons lived in the cities and towns and the remainder were located on farms. Since 1920 there has been a steady decrease in the farm population and an equally steady trend upward for urban districts, which indicate that industrial and service operations are becoming increasingly important throughout the entire Sub-division. Mining and oil production and refining operations have been centered in the western high plains, the mountainous sections, and in the western plains. Food processing and the manufacturing of heavy machinery is found principally in the eastern section. The mountainous areas of Colorado have been the vactionland of great numbers of persons for many years. The income from tourist trade represents a substantial portion of the income of Colorado and Wyoming residents. The water resources add greatly to the enjoyment of this region by vacation-minded people. Recreational facilities throughout the remainder of the Sub-division are very limited. Characteristics of the streams of the plains region are such that they do not lend themselves easily to the propagation of fish life. Fish and wildlife developments therefore are more or less limited to the conservation reservoirs constructed in recent years.

The contemplated development of the water resources should materially increase the water supplies available to the cities both from surface and underground sources. The acreage which may be profitably irrigated will increase substantially, a factor which undoubtedly will help stabilize the economy of the entire Missouri Basin. It is also expected that there will be a substantial increase in the farm population when a stabilized farm economy can be virtually assured. In the meantime it would appear that the urban districts will continue to grow and industry will occupy an increasingly important position in the economy of the Niobrara, Platte, and Kansas River Sub-division.

The principal trade centers are Denver, Colorado; Cheyenne and Casper, in Wyoming; North Platte, Kearney, Grand Island, Norfolk, Fremont, and Lincoln, in Nebraska; Topeka, Manhattan, Salina, and Kansas City, in Kansas. These cities are interconnected by railroads and highways, and with transportation systems and markets now readily available, it is likely that these cities will continue to grow. This growth may affect the water resources in a number of ways; first, it will necessitate a larger proportion of water for municipal and industrial use; and secondly, problems of both domestic and industrial pollution will increasingly affect the condition of the streams. Water usage will be greatly restricted in those areas immediately below large centers of population and industrial operations, unless adequate measures for the control of pollution are incorporated in the overall water resources development program.

Sources of Pollution

Sources of pollution and pertinent data are illustrated on Map No. 8. There are 303 cities and towns located in this Sub-division which contribute either raw or treated sewage to streams and waterways from an estimated 1,387,900 persons served by sanitary sewer systems. Waste discharged from municipal sewer systems, including both treated and raw wastes from domestic and industrial sources, is estimated to be equivalent to a population of 3,436,800 persons. This figure is subject to revision pending receipt of additional information from both census reports and industrial waste investigations under way at this time.

There are 62 industries of major proportions estimated to have a waste population equivalent of 2,127,750 persons discharging into streams. At least 20 of these industries operate seasonally and discharge wastes in the fall of the year when flow in most streams is at a minimum. The total waste discharge to streams of the Sub-division is estimated to be equivalent to that produced by 5,565,000 persons of which 75 percent originates from industrial operations. In addition to the population equivalent of these wastes, a considerable amount of mineral contamination and toxic material is discharged to streams from oil production and refining. Toxic and mineral contamination is serious since the contaminants are not readily removed by the natural purification processes occurring in the streams. Pollution in central Kansas streams by wastes from oil and gas fields has been greatly reduced by control methods, although some still persists. Oil refinery wastes contribute significant amounts of pollution to the North Platte in and below Casper, Wyoming. Both the North and South Platte Rivers are recipients of vast amounts of industrial waste from sugar refineries during their seasonal operation.

The cities of Denver, Colorado and Kansas City, Kansas, by virtue of their population and industrial importance, contribute a large percentage of the waste load. Pollution from Denver, after primary treatment, is discharged to the South Platte River. Wastes from Kansas City, Kansas are discharged into the Kansas River just above its confluence with the main stem of the Missouri River. There are numerous other communities where local nuisance conditions have developed in water courses immediately below the points of discharge as the result of the putrefaction of domestic and industrial wastes.

Water Use and Adequacy Of Water For Indicated Uses

Water uses in this Sub-division are illustrated on Map No. 9. Water resources of the Niobrara, Platte, and Kansas Subdivision have been more highly developed than in any other region of the Missouri Basin. Irrigation has long been practiced in the Platte system and to a lesser extent in the Kansas River system. A large percentage of the water utilized has come from the surface streams, however ground waters have been extensively used in the central Nebraska region on the Lower Platte and near Fort Morgan in Colorado on the South Platte. Demand for municipal use has also been large. It is estimated that domestic water consumption from both surface and ground water sources is approximately 220 million gallons per day or 245,550 acre-feet annually. About 55 percent of this volume of water is taken from surface streams and the remainder from ground water sources. An analysis of these figures indicates that approximately 110,000 acre-feet of water in the form of sewage may be added to the natural flow of the streams of this Sub-division by virtue of municipal use of ground water. Water taken from streams by municipalities is of course returned in substantially the same volume but in the form of sewage. It is estimated that water supplied through municipal systems costs the immediate consumer $19,300,000 annually. Its value to the consumer is much greater.

Considerable use of surface streams is made by industry. Power plants located on the Kansas River near Topeka and Lawrence, Kansas have a combined use of 180 million gallons per day for cooling purposes. It is reported that flows in the Kansas River of less than 110 million gallons per day will necessitate curtailment of power production. Often neglected is the value of streams for emergency use during national crisis. An ordnance plant on the Kansas River, now maintained on a standby basis, purified 43 million gallons of river water each day for process use during the past war. In the Platte River system, power use is of tremendous value and directly related to the irrigation development. Hydroelectric installations will have a capacity of over 2 billion KVA's annually when present construction programs have been completed.

There are several areas within this Sub-division where water from either ground or surface sources is inadequate in volume to supply the demand. The most critical area is that at and immediately below Denver, Colorado. This problem is being met by the diversion of water from the Colorado River across the Continental Divide into the Big Thompson River thence to the South Platte for the use of the City of Denver and irrigation interests immediately below. Excessive pumpage of ground waters in central Nebraska has lowered the water table which has resulted in increasing the mineral content of the water and has added greatly to the costs of pumping. Lincoln, Nebraska, located in an area less abundantly endowed with ground water, has been particularly affected in this manner. Municipalities located along Ponca Creek in northern Nebraska and southern South Dakota have been unable to obtain sufficient ground water to meet their demands and will find it necessary to augment their well supplies with surface sources in the very near future. The value of the water resources of this Sub-division is considered very great because of extensive use of irrigation and the increasing demands of the expanding urban population and attending industrial operations. In the headwater regions of the Platte, streams are extremely valuable for game fishing and other recreational purposes. Considerable stretches of both the North and South Platte Rivers are, at present, valueless for game fishing and recreational purposes and the value of the water depreciated for irrigation purposes and domestic water supply because of municipal and industrial pollution. The actual depreciation is extremely difficult to ascertain but nevertheless great. Irrigation of truck gardens, such as those immediately below Denver, Colorado, with sewage ladened waters is believed to be an extremely hazardous practice by most health authorities. It is reported that the flows diverted from the South Platte River immediately below Denver contain at times as much as 70 percent sewage.

Need For Treatment Works

Summary of the sewage treatment needs and of existing works is shown in Tables No. 9 and No. 10. Eighty-five new plants are needed, and of the 218 plants now in existence 20 should be rebuilt or improved as required. The condition of 25 other plants is unknown. Data available for 128 small towns are insufficient to classify their treatment needs. Twenty of the 62 or more industrial plants discharging waste directly into streams are known to need treatment, but available data are too limited to indicate whether or not additional plants may be needed. It is estimated that the cost of new plants and improvements needed immediately by municipalities would approximate $10,000,000. It is difficult to supply a figure for the industrial plants; however it may ultimately cost $5,000,000 for industry to provide facilities equivalent to primary treatment. It has been reported that the oil production industry alone has spent more than $15,000,000 in the State of Kansas to control and dispose of wastes produced. The cost figure cited does not include the annual charge for operation and maintenance.

TABLE 9

NIOBRARA, PLATTE, AND KANSAS SUB-DIVISION

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	431	1,387,900	3,436,794
Industrial Plants b/	62		*2,127,750 (Est.)
Total	493	1,387,900	5,564,544

* Toxic materials from oil production and processing.
Seasonal - Beet sugar refineries responsible for a large proportion, there may be more industrial plants to be classified upon receipt of further information.

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the nonsimilar wastes in terms of a common unit Population Equivalent.

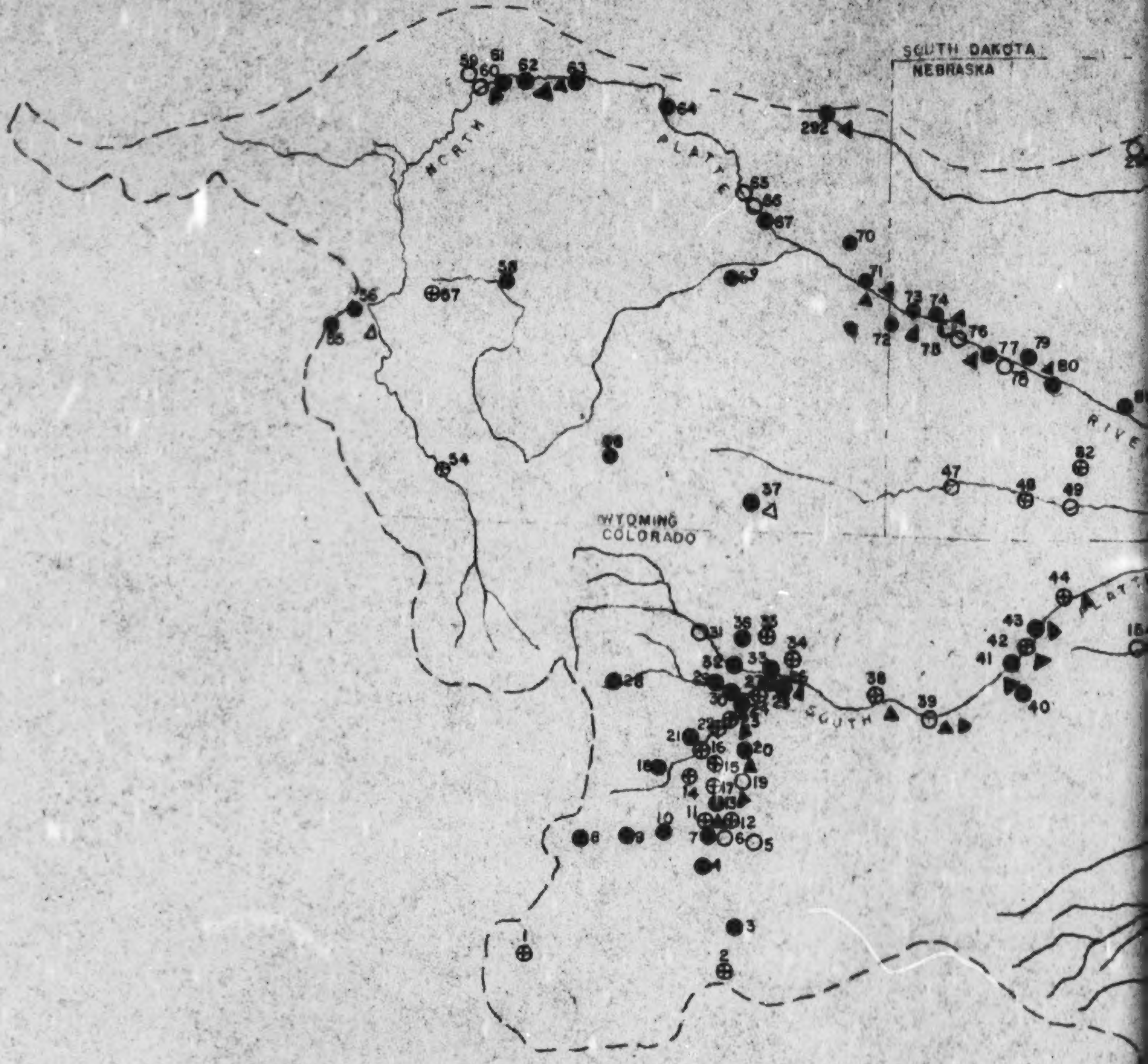
TABLE 10

NIOBRARA, PLATTE, AND KANSAS SUB-DIVISION

Sewage and Industrial Waste Treatment Plant Requirements

		Without Treatment			With Treatment				
Source (1)	Total No. (2)	No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)	No Project Req'd (9)	No Data (10)
Municipalities	431	85	65	20	218	20	25	173	128
Industrial Plants	62	20	20	*					42
Total	493	105	85	20	218	20	25	173	170

* Other plants may be located pending receipt of more information.


SOUTH DAKOTA
NEBRASKA
WYOMING
COLORADO
NORTH
PLATTE
RIVE
SOUTH
PLATT
59
60
61
62
63
64
292
65
66
67
70
71
72
73
74
76
77
78
79
80
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47
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12
11
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9
8
7
6
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3
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1
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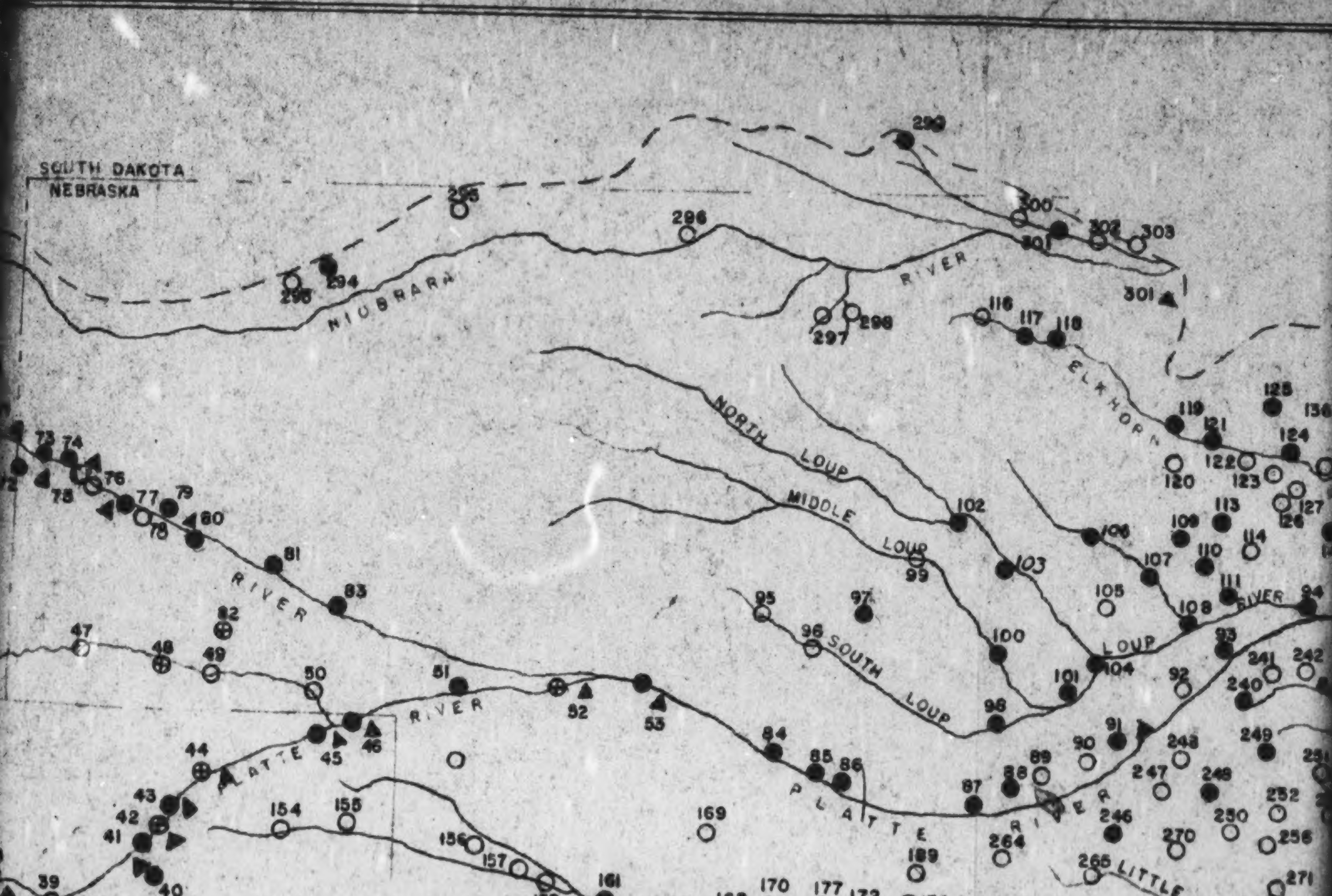
57
58
69

See pages ~~54~~ 37 to ~~57~~ 40 for names of Sources of Pollution.

MAR NO. 8


SOUTH DAKOTA
NEBRASKA
NIOBRARA
RIVER
ELKHORN
NORTH LOUP
MIDDLE LOUP
SOUTH LOUP
LOUP
RIVER
RIVER
PLATTE
RIVER
PLATTE
RIVER
LITTLE BLUE
NEBRASKA
KANSAS
REPUBLICAN
RIVER
SOLOMON
RIVER
SALINE
RIVER
SMOKY HILL
RIVER

8

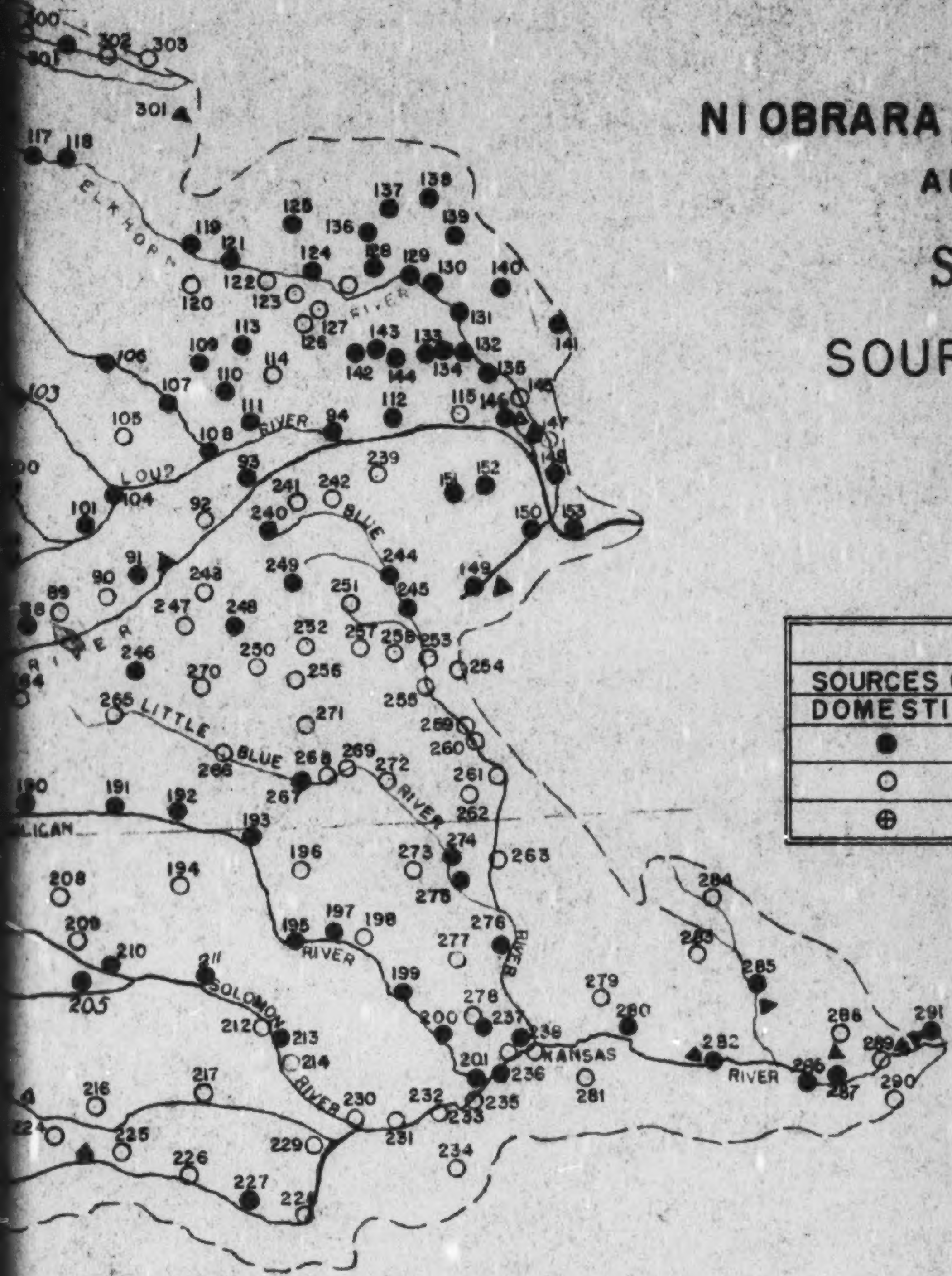
MAY 1950

NIOBRARA, PLATTE, & KANSA

AND THEIR TRIBUTARIE

SUB-DIVISION

SOURCES OF POLLU


300
302
303
301
301
117
118
ELKHORN
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129
130
140
RIVER
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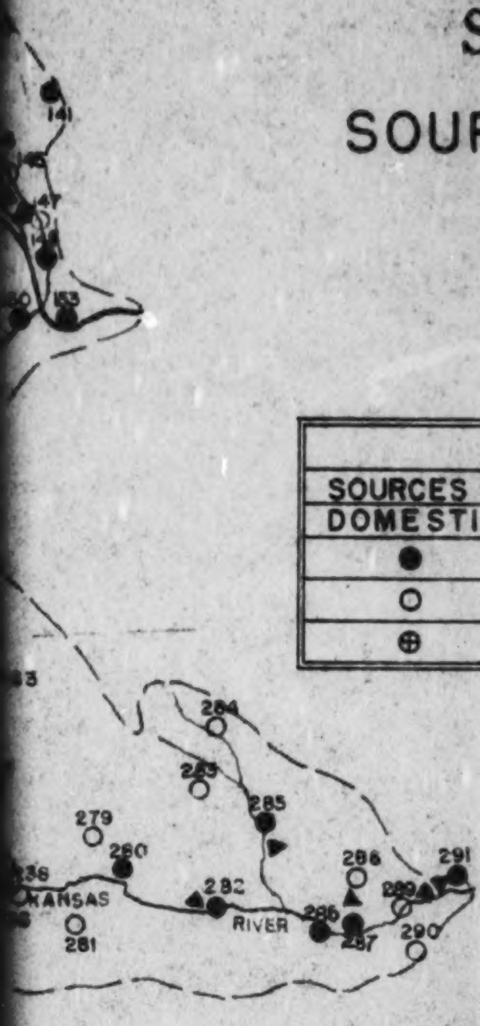
135
110
103
107
112
115
146
145
111
94
147
105
RIVER
108
LOUP
93
239
151
152
148
100
241
242
104
101
92
240
BLUE
150
153
91
249
244
149
90
89
243
251
245
88
247
248
252
257
258
253
RIVER
246
250
254
270
256
84
255
265
LITTLE
271
259
260
BLUE
266
268
269
272
261
267
RIVER
190
191
192
262
LICAN
193
196
273
274
263
208
194
275
284
209
197
198
276
195
277
283
210
RIVER
RIVER
285
211
199
205
279
SOLOMON
278
280
212
213
200
237
238
288
291
214
282
KANSAS
289
201
236
RIVER
286
287
217
281
290
216
232
230
RIVER
235
233
224
225
231
229
226
234
227
228

L E G E N D		
SOURCES OF POLLUTION		STAT
DOMESTIC	INDUSTRIAL	
●	▲	TREATMEN
○	△	NO TREATMEN
⊕	▲	UNKNOWN S

MAY 1950



141
147
153
284
283
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281
287
KANSAS
RIVER

NIOBRARA, PLATTE, & KANSAS RIVERS
AND THEIR TRIBUTARIES
SUB-DIVISION
SOURCES OF POLLUTION

LEGEND

SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	◬	UNKNOWN STATUS

KEY TO MAP SHOWING SOURCES OF POLLUTION IN THE

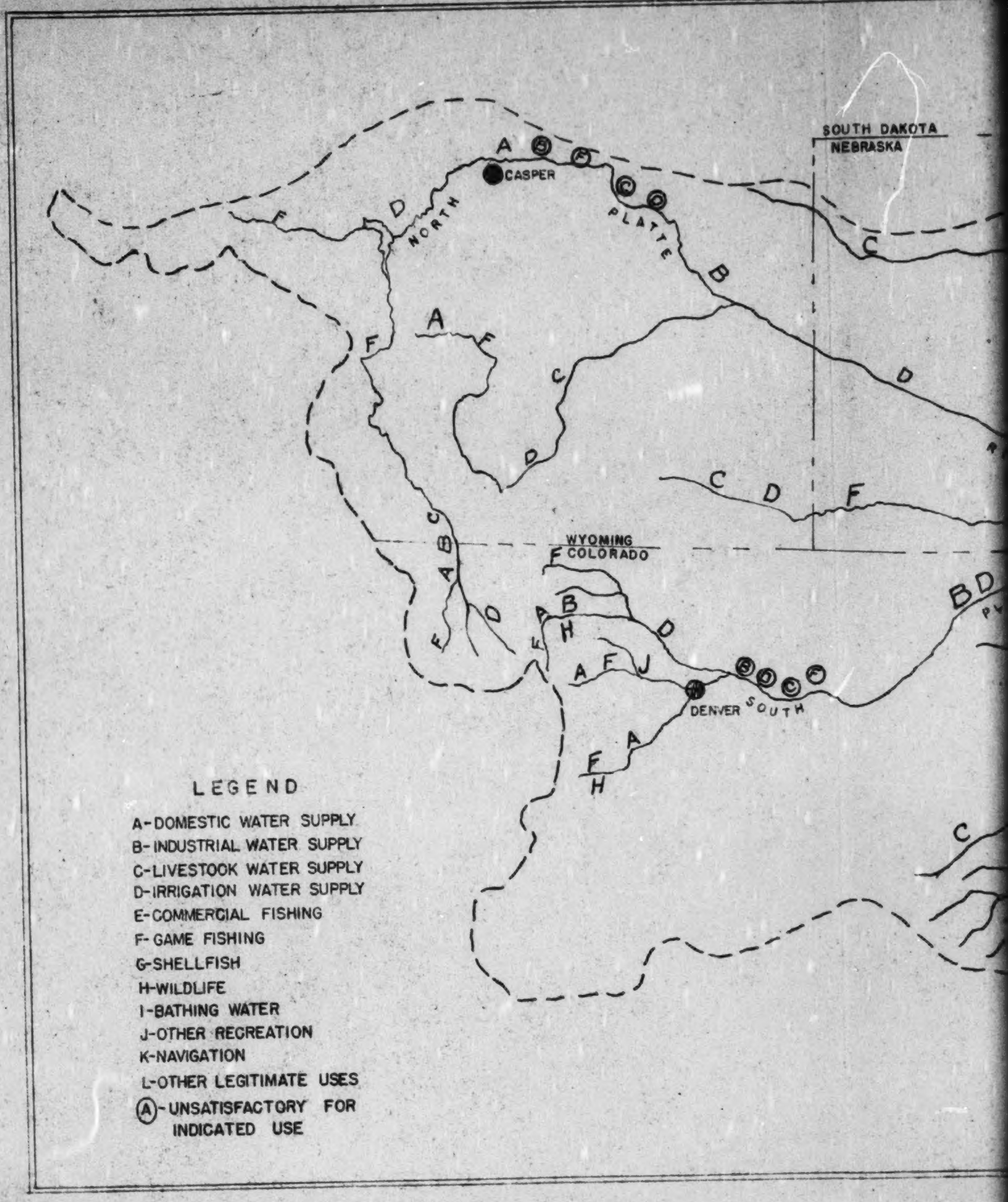
NIOBRARA, PLATTE AND KANSAS SUB-DIVISION

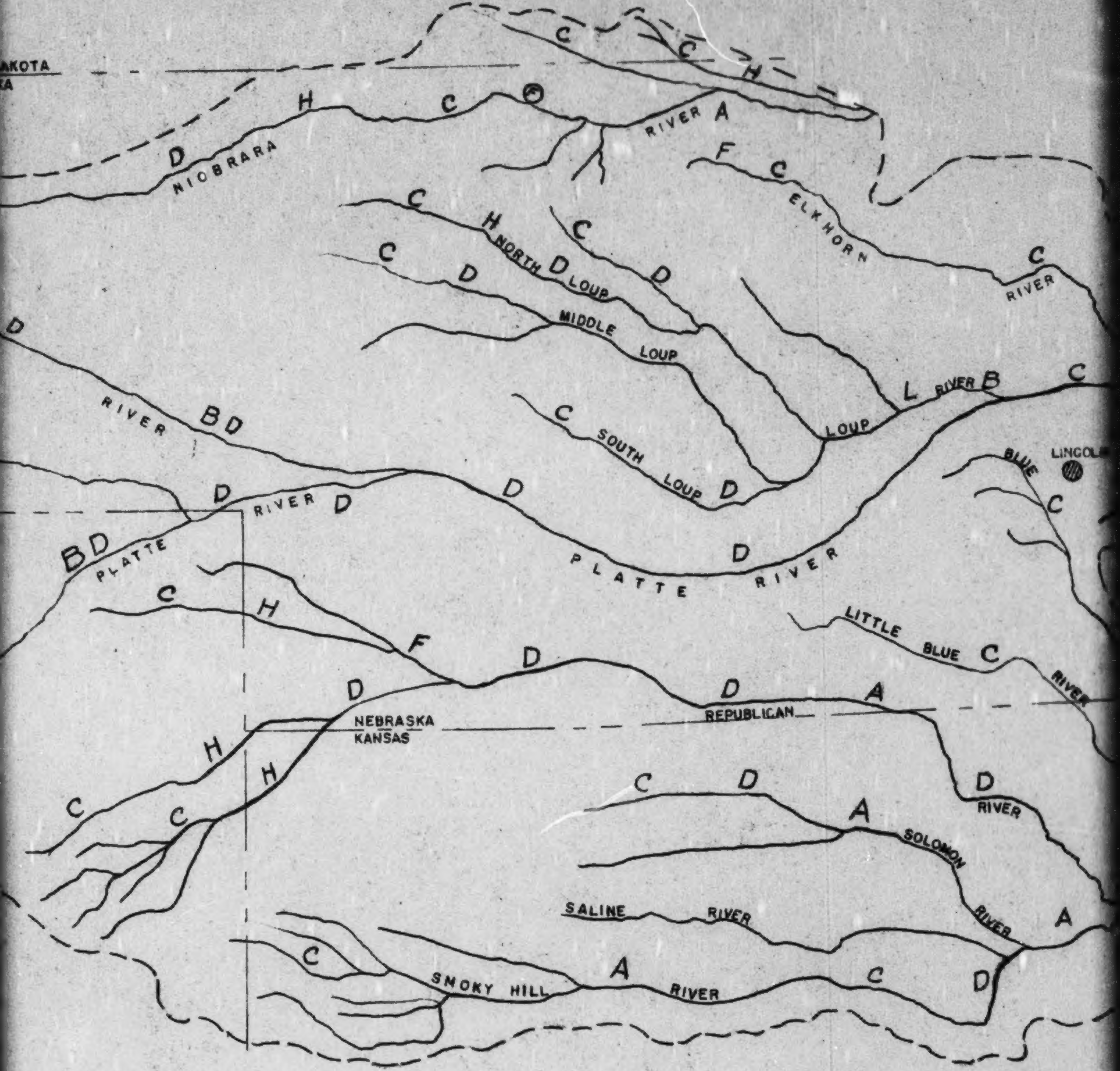
1. Fairplay, Colo.
2. Palmer Lake, Colo.
3. Castle Rock, Colo.
4. Littleton, Colo.
5. Fitzsimmons, Colo.
6. Buckley Field, Colo.
7. Denver, Colo.
8. Georgetown, Colo.
9. Idaho Springs, Colo.
10. Golden, Colo.
11. Westminister, Colo.
12. Aurora, Colo.
13. Arvada, Colo.
14. Louisville, Colo.
15. LaFayette, Colo.
16. Frederick, Colo.
17. Nederlands, Colo.
18. Boulder, Colo.
19. Brighton, Colo.
20. Fort Lupton, Colo.
21. Longmont, Colo.
22. Erie, Colo.
23. Lyons, Colo.
24. Platteville, Colo.
25. Gilcrest, Colo.
26. LaSalle, Colo.
27. Evans, Colo.
28. Estes Park, Colo.
29. Loveland, Colo.
30. Johnstown, Colo.
31. Fort Collins, Colo.
32. Windsor, Colo.
33. Greeley, Colo.
34. Wellington, Colo.
35. Ault, Colo.
36. Eaton, Colo.
37. Cheyenne, Wyo.
38. Orehard, Colo.
39. Fort Morgan, Colo.
40. Brush, Colo.
41. Merino, Colo.
42. Atwood, Colo.
43. Sterling, Colo.
44. Iliff, Colo.
45. Ovid, Colo.
46. Julesburg, Colo.
47. Kimball, Nebr.
48. Brule, Nebr.
49. Sidney, Nebr.
50. Chappel, Nebr.
51. Ogalalla, Nebr.
52. Paxton, Nebr.
53. North Platte, Nebr.
54. Saratoga, Wyo.
55. Rawlins, Wyo.
56. Sinclair, Wyo.
57. Hanna, Wyo.
58. Medicine Bow, Wyo.
59. Casper A.B., Wyo.
60. B. of R. Housing, Wyo.
61. Casper, Wyo.
62. Evansville, Wyo.
63. Glenrock, Wyo.
64. Douglas, Wyo.
65. Sunrise, Wyo.
66. Hartville, Wyo.
67. Guernsey, Wyo.
68. Laramie, Wyo.
69. Wheatland, Wyo.
70. Lingle, Wyo.
71. Torrington, Wyo.
72. Lyman, Nebr.
73. Morrill, Nebr.
74. Mitchell, Nebr.
75. Scottsbluffs, Nebr.
76. Gering, Nebr.
77. Minatare, Nebr.
78. Melbeta, Nebr.
79. Bayard, Nebr.
80. Bridgeport, Nebr.
81. Broadwater, Nebr.
82. Gurley, Nebr.
83. Oshkosh, Nebr.
84. Gothenburg, Nebr.

85. Cozad, Nebr.
86. Lexington, Nebr.
87. Kearney, Nebr.
88. Gibbon, Nebr.
89. Shelton, Nebr.
90. Wood River, Nebr.
91. Grand Island, Nebr.
92. Central City, Nebr.
93. Silver Creek, Nebr.
94. Columbus, Nebr.
95. Arnold, Nebr.
96. Calloway, Nebr.
97. Broken Bow, Nebr.
98. Ravenna, Nebr.
99. Sargent, Nebr.
100. Loup City, Nebr.
101. Dannebrog, Nebr.
102. Burwell, Nebr.
103. Ord, Nebr.
104. St. Paul, Nebr.
105. Wolbach, Nebr.
106. Spalding, Nebr.
107. Cedar Rapids, Nebr.
108. Fullerton, Nebr.
109. Albion, Nebr.
110. St. Edwards, Nebr.
111. Genoa, Nebr.
112. Schuyler, Nebr.
113. Newman Grove, Nebr.
114. Lindsay, Nebr.
115. North Bend, Nebr.
116. Stuart, Nebr.
117. Atkinson, Nebr.
118. O'Neill, Nebr.
119. Neleigh, Nebr.
120. Elgin, Nebr.
121. Tilden, Nebr.
122. Meadow Grove, Nebr.
123. Battle Creek, Nebr.
124. Norfolk, Nebr.
125. Pierce, Nebr.
126. Humphrey, Nebr.
127. Stanton, Nebr.
128. Pilger, Nebr.
129. Wisner, Nebr.
130. Beemer, Nebr.
131. West Point, Nebr.
132. Scribner, Nebr.
133. Dodge, Nebr.
134. Snyder, Nebr.
135. Hooper, Nebr.
136. Winside, Nebr.
137. Wayne, Nebr.
138. Wakefield, Nebr.
139. Pender, Nebr.
140. Lyons, Nebr.
141. Oakland, Nebr.
142. Leigh, Nebr.
143. Clarkson, Nebr.
144. Howells, Nebr.
145. Arlington, Nebr.
146. Fremont, Nebr.
147. Valley, Nebr.
148. Waterloo, Nebr.
149. Lincoln, Nebr.
150. Ashland, Nebr.
151. Weston, Nebr.
152. Wahoo, Nebr.
153. Louisville, Nebr.
154. Haxtun, Colo.
155. Holyoke, Colo.
156. Imperial, Nebr.
157. Wauneta, Nebr.
158. Palisade, Nebr.
159.
160. Grant, Nebr.
161. Culbertson, Nebr.
162. Wray, Colo.
163. St. Francis, Kansas
164. Benkelman, Nebr.
165. Stratton, Nebr.
166. Trenton, Nebr.
167. McCook, Nebr.
168. Indianaola, Nebr.
169. Curtis, Nebr.
170. Cambridge, Nebr.
171. Holbrook, Nebr.
172. Arapahoe, Nebr.
173. Oxford, Nebr.
174. Bertrand, Kansas
175. Goodland, Kansas
176. Brewster, Kansas
177.
178. Oberlin, Kansas
179. Burlington, Kansas
180. Atwood, Kansas

181. Herdon, Kansas
182. Beaver City, Nebr.
183. Orleans, Nebr.
184. Alma, Nebr.
185. Colby, Kansas
186. Norton, Kansas
187. State Sanatorium, Norton, Kansas
188. Almena, Kansas
189. Holdrege, Nebr.
190. Franklin, Nebr.
191. Red Cloud, Nebr.
192. Superior, Nebr.
193. Scandia, Kansas
194. Mankato, Kansas
195. Concordia, Kansas
196. Belleville, Kansas
197. Clyde, Kansas
198. Clifton, Kansas
199. Clay Center, Kansas
200. Wakefield, Kansas
201. Junction City, Kansas
202. Hoxie, Kansas
203. Hill City, Kansas
204. Stockton, Kansas
205. Osborne, Kansas
206. Logan, Kansas
207. Phillipsburg, Kansas
208. Smith Center, Kansas
209. Gaylord, Kansas
210. Downs, Kansas
211. Beloit, Kansas
212. Glasco, Kansas
213. Delphos, Kansas
214. Minneapolis, Kansas
215. Plainville, Kansas
216. Sylvan Grove, Kansas
217. Lincoln, Kansas
218. Cheyenne Wells, Colo.
219. Sharon Springs, Kansas
220. Oakley, Kansas
221. Wakeeney, Kansas
222. Ellis, Kansas
223. Hays, Kansas
224. Russell, Kansas
225. Wilson, Kansas
226. Ellsworth, Kansas
227. Marquette, Kansas
228. Lindsborg, Kansas
229. Salina, Kansas
230. Solomon, Kansas
231. Abilene, Kansas
232. Enterprise, Kansas
233. Chapman, Kansas
234. Herington, Kansas
235. Fort Riley, Kansas
236. Ogden, Kansas
237. Manhattan, Kansas
238. Wamego, Kansas
239. David City, Nebr.
240. Stromsburg, Nebr.
241. Osceola, Nebr.
242. Shelby, Nebr.
243. Aurora, Nebr.
244. Seward, Nebr.
245. Milford, Nebr.
246. Hastings, Nebr.
247. Harvard, Nebr.
248. Sutton, Nebr.
249. York, Nebr.
250. Fairmont, Nebr.
251. Beaver Crossing, Nebr.
252. Exeter, Nebr.
253. Crete, Nebr.
254. Dorchester, Nebr.
255. Wilbur, Nebr.
256. Geneva, Nebr.
257. Friend, Nebr.
258. DeWitt, Nebr.
259. State Home, Beatrice, Nebr.
260. Beatrice, Nebr.
261. Wymore, Nebr.
262. Jansen, Nebr.
263. Marysville, Kansas
264. Minden, Nebr.
265. Blue Hill, Nebr.
266. Ayr, Nebr.
267. Hebron, Nebr.
268. Edgar, Nebr.
269. Davenport, Nebr.
270. Clay Center, Nebr.
271. Bruning, Nebr.
272. Fairbury, Nebr.
273. Washington, Kansas
274. Hanover, Kansas
275. Waterville, Kansas
276. Blue Rapids, Kansas

277. Axtell, Kansas
278. Frankfort, Kansas
279. Onaga, Kansas
280. St. Marys, Kansas
281. Alma, Kansas
282. Topeka, Kansas
283. Horton, Kansas
284. Holton, Kansas
285. Valley Falls, Kansas
286. Lawrence, Kansas
287. Eudora, Kansas
288. Tonganoxie, Kansas
289. DeSoto, Kansas
289-A Bonner Springs, Kansas
290. Olathe, Kansas
291. Kansas City, Kansas
292. Lusk, Wyo.
293. Hay Springs, Nebr.
294. Rushville, Nebr.
295. Gordon, Nebr.
296. Valentine, Nebr.
297. Ainsworth, Nebr.
298. Long Pine, Nebr.
299. Gregory, S.D.
300. Butte, Nebr.
301. Spencer, Nebr.
302. Lynch, Nebr.
303. Verdel, Nebr.


SOUTH DAKOTA
NEBRASKA
WYOMING
COLORADO
CASPER
DENVER
NORTH
PLATTE
SOUTH
LEGEND
A-DOMESTIC WATER SUPPLY
B-INDUSTRIAL WATER SUPPLY
C-LIVESTOOK WATER SUPPLY
D-IRRIGATION WATER SUPPLY
E-COMMERCIAL FISHING
F-GAME FISHING
G-SHELLFISH
H-WILDLIFE
I-BATHING WATER
J-OTHER RECREATION
K-NAVIGATION
L-OTHER LEGITIMATE USES
Ⓐ-UNSATISFACTORY FOR INDICATED USE


AKOTA
KA
C
C
H
H
C
Ⓕ
RIVER A
D
NIOBRARA
F
C
ELKHORN
C
RIVER
C
H
NORTH
D
LOUP
C
D
C
D
MIDDLE
LOUP
D
RIVER
BD
L
RIVER
B
C
LOUP
C
SOUTH
LOUP
D
D
RIVER
D
D
LINCOL
BLUE
C
BD
PLATTE
PLATTE
D
RIVER
C
H
F
D
LITTLE
BLUE
C
RIVER
D
D
A
REPUBLICAN
NEBRASKA
KANSAS
H
H
C
C
C
D
A
D
RIVER
SOLOMON
RIVER
SALINE
RIVER
A
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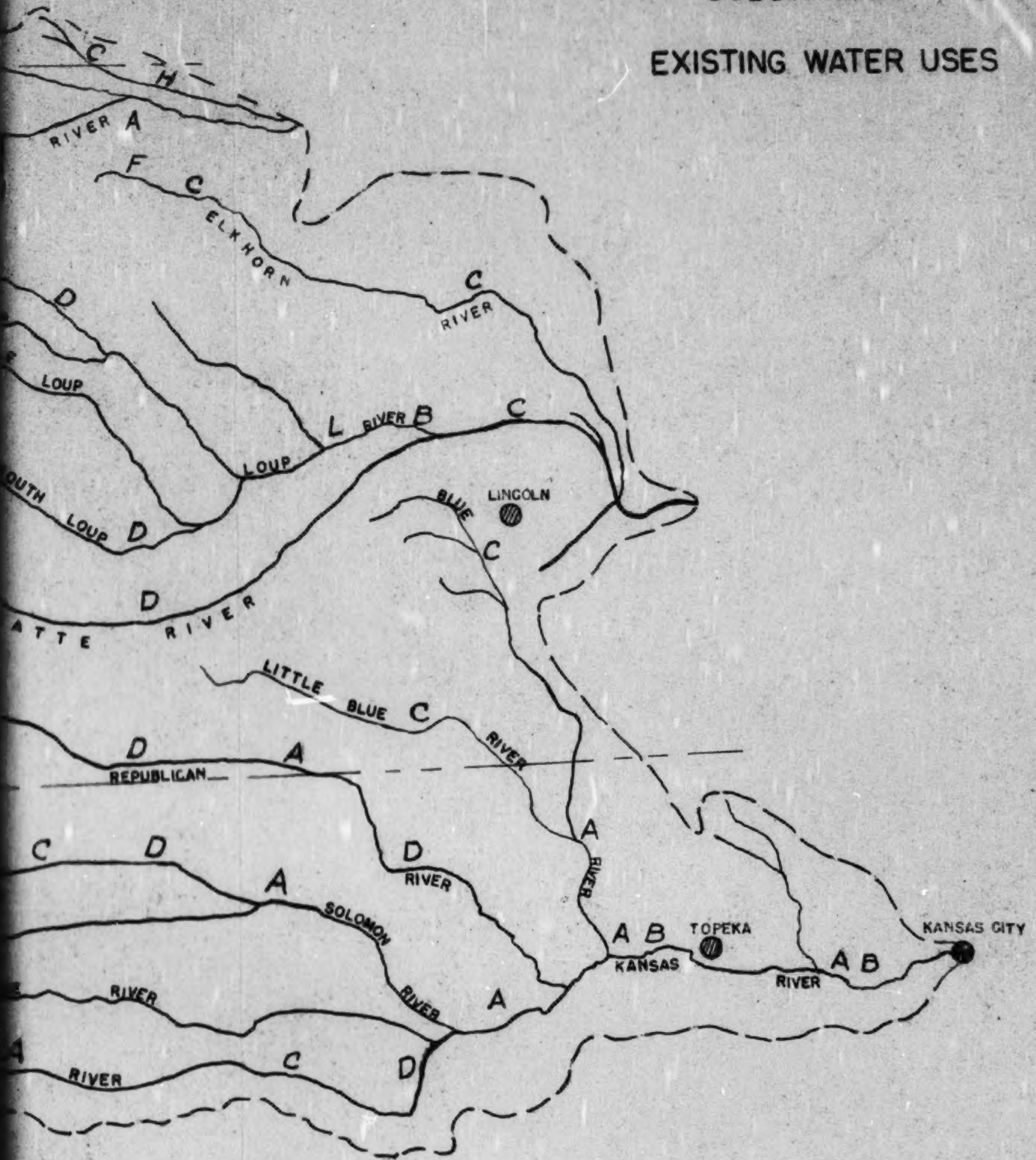
SMOKY HILL
RIVER
C
D

NIOBRARA, PLATTE AND KANSAS SUBDIVISION

EXISTING WATER USES


C
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LOUP D
LINCOLN
BLUE
C
D
ATTE
RIVER
LITTLE
BLUE C
RIVER
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REPUBLICAN
A
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A
RIVER
RIVER
SOLOMON
A B
TOPEKA
KANSAS CITY
KANSAS
RIVER
A B
RIVER
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MAP NO. 9 MAY 1950

THE LOWER MISSOURI RIVER SUB-DIVISION

Description of Sub-Division

The Lower Missouri River Sub-division consists of that area drained by the main stem of the river from Sioux City to the mouth, excluding the Platte and Kansas River Basins. Past records indicate that the daily flow of the Missouri River at Sioux City averaged 20,000 second-feet, and at the mouth 66,400 second-feet. Unregulated daily low flows at the same two points may drop to as low as 2,500 and 10,000 second-feet, respectively. The river is generally heavily laden with silt throughout this entire reach. The velocity of flow is quite rapid because of the fairly steep average gradient of .85 feet per mile over the 810 mile stretch. The main tributaries, excluding those already mentioned, are the Big Sioux, Little Sioux, Boyer, Nishnabotna, Nodaway, Grand, Chariton, Osage, Gasconade, and Nemaha Rivers. These streams are characterized by their generally muddy appearance and damaging floods which occur frequently.

Rainfall in this Sub-division ranges from 22 inches in the northern and westernmost sections to 40 inches or more in the southeastern section. Surface runoff is greater in this region than in any other part of the Missouri Basin. Precipitation occurs from storms, originating both in the northwest and in the Gulf of Mexico, which usually approach from either the northwest or from the southwest and travel eastward. It is not uncommon for violent rain or snow storms to occur simultaneously over large but different sections of the area. Temperatures are considerably milder than in the other Sub-divisions, the average mean annual temperature being approximately 53°F. Recorded extreme temperatures are -38° and 112°. The relative humidity for the region is also considerably higher than other sections.

The topography may be described as broad expanses of rolling to hilly uplands, interspersed with comparatively narrow valleys, excepting however, the Ozark uplift in central Missouri. The soils of the entire region, with the exception of the Ozarks, are highly productive, both in the uplands and in the valleys. The erosion of this productive soil by the great amount of runoff is posing a major problem for agricultural interests.

Ground water is available in moderate amounts over the entire Sub-division; however, it is generally quite highly mineralized, particularly in the Big and Little Sioux River Basins, and that portion of the Sub-division lying along the boundary of Iowa and

Missouri. Sioux Falls, South Dakota, has developed its underground water sources to the maximum. Several small cities and towns in southern Iowa have found it necessary to implement their ground water supplies with surface water. The only area where copious supplies of water can be obtained easily are those located in the adjacent flood plain of the main stem of the Missouri River. This water has a hardness averaging approximately 20 grains per gallon and a variable amount of iron, most of which is far in excess of that considered satisfactory for domestic use. There have been few attempts to develop irrigation projects with ground or surface water resources.

The development of the mineral resources of the region is limited to those used for construction materials and to the bituminous coal deposits found in southern Iowa and north central Missouri. The Ozarks support the only forests to be found within the region, and these have been greatly reduced in recent years. There are few natural recreational areas within the Sub-division.

The population of the Lower Missouri River Sub-division was 3,800,000 in 1940, approximately 40 percent of which resided in the rural district. Agricultural pursuits are quite intensive in this Sub-division and represent in value about 45 percent of all agricultural products grown in the entire Missouri River Basin. The farms are small and are usually without irrigation. There has been a general decline in the rural population since 1920, while during the same period the urban populations have been steadily increasing. The movement of population from rural to urban districts has had little or no effect on the farm production, since modern farming machinery has enabled farmers to till larger acreages and thereby produce much more than previously.

Industrial operations within the area are growing fast, and consist principally of those associated with the processing of foodstuffs, manufacture of machinery, transportation and marketing.

Surface water resources of the lower river basin have been developed heretofore principally for the use of municipalities and for navigation. The high silt content and the frequent flooding of the streams has not been conducive to fish propagation. Recreation and fishing, in which water played a part, has been limited to those areas in which storage reservoirs have been constructed for various purposes. The rather extensive urban population has focused attention on these water resources for both municipal water supply and sanitation. The value of these water resources for domestic and sanitary purposes is very great since population and industrial growth would be stifled if their needs could not be met. The principal cities are Sioux Falls in South Dakota; Sioux City and Council Bluffs in Iowa; Omaha in Nebraska; Leavenworth and

Kansas City in Kansas; St. Joseph, Kansas City, Jefferson City, and the metropolitan area of St. Louis County in Missouri. These cities, contain approximately one-third of the Basin's population and two-thirds of its industry, and are located in the downstream part of the Missouri Basin. As efforts towards the conservation of water resources have been affected in the headwater streams, it is highly important that the municipal and industrial needs of these cities as related to water be examined along with the numerous other water uses contemplated.

Sources of Pollution

There are 587 municipalities in the Lower Missouri Subdivision which have more than 250 inhabitants each. Map No. 10 illustrates sources of pollution with pertinent information. Of these municipalities 342 are known to have sanitary sewer systems which serve in total 1,421,571 persons. Industrial operations contribute waste estimated to be equivalent to a population of approximately 1,300,000 persons, most of which is discharged without treatment to the streams. It is estimated that the total population equivalent of waste discharged, including both treated and untreated, is approximately that of 2,500,000 persons.

Centers of population such as Sioux City, Iowa, Omaha, Nebraska, St. Joseph, Kansas City, and St. Louis County in Missouri, contribute a large portion of the industrial and domestic wastes. However in many instances the effects of stream pollution are much more acute in the streams immediately below smaller cities and towns. The greatest proportion of the industrial wastes being discharged directly into the main stem of the Missouri River is from the meat packing plants and stockyards located in Sioux City, Iowa, Omaha, Nebraska, and St. Joseph, Missouri. It is significant that only one of the larger centers of population located on the main stem of the Missouri River has provided any treatment for either domestic or industrial wastes. Omaha, Nebraska, has provided primary treatment for a limited number of people residing within the municipality but located on a watershed of a small stream tributary to the Missouri River. There are numerous food processing plants such as canneries, creameries, slaughter houses, and poultry packing plants located in the smaller communities of Iowa, Missouri, Nebraska, South Dakota, and Kansas, which contribute greatly to local stream pollution. The creameries, poultry packing plants, and slaughter houses are for the most part located within the municipalities, and therefore discharge their wastes directly into the municipal sewer systems. The canneries are usually located outside the cities and discharge their wastes directly into the streams.

The smaller cities and towns located in the Lower Missouri Sub-division on other than the main stem of the Missouri River will not benefit directly from the proposed water use program. The larger centers located on the main stem of the Missouri River may find a minimum regulated flow to their advantage for sanitary purposes during those periods of time which are critical under natural flow conditions. Drainage from the strip coal mining areas of northern Missouri and southern Iowa add acid mine wastes to the streams thereby greatly deteriorating the quality of the waters of these local streams.

Water Use and Adequacy of Water for Those Uses

Rainfall in this Sub-division is usually sufficient to provide moisture necessary for the growing of crops, making irrigation unnecessary. Flood control is an important aspect of water control in this Sub-division. The waters of the main stem of the Missouri River have heretofore been used primarily as a source of municipal water supply and for navigation. Commercial fishing has been carried on in a minor respect. The use of tributary streams in this Sub-division as a source of municipal water supply has been limited to those areas in which ground water is either chemically unsuited for domestic use or is not available in sufficient quantities to be of appreciable value. The areas affected in this manner are located in the Big Sioux Basin and on either side of the state line between Iowa and Missouri. Ground water, in sufficient quantity for local domestic needs, is generally available throughout the entire lower basin, with the exception of large cities and those areas already cited. However its chemical quality is not satisfactory for many domestic uses, and would be supplanted in many instances with the better quality surface waters should they be made available at reasonable costs. The control of the surface resources on the smaller tributary streams would also add greatly to efforts towards controlling the effects of pollution in those streams.

The municipalities of the Lower Missouri Sub-division use an estimated 215 million gallons of water per day, of which 165 million gallons is taken from surface sources, and the remainder from ground water sources. The total volume of water used through municipal systems would amount to 238,000 acre-feet per year, at a cost of approximately $15,700,000 to the consumers. This volume of water does not include that used by all industrial operations. The use of water by municipalities is not generally considered a consumptive use of water inasmuch as it is returned to the streams in the form of sewage. The largest municipal water use demands are made by Omaha, Nebraska, Kansas City, Missouri, and St. Louis

County, Missouri, whose systems take their water directly from the main stem of the river.

The water resources of the Sub-division are generally sufficient to meet the present demands of municipalities and industrial plants; however they are insufficient on the smaller tributaries for sanitation purposes, which necessitates expensive sewage treatment works in most of the small communities. It is believed that a comprehensive water resources development program for the Lower Missouri Basin would greatly assist the municipalities in satisfying the demand of the urban population for good water for domestic uses and sanitary purposes. Such a program would undoubtedly assist the further industrial development of the area, and would also increase the number of areas used for recreation and the propagation of fish. Both of these latter uses have heretofore been severely limited by unsatisfactory stream conditions.

The effect of the development program in the upper reaches of the river on the municipal water uses in the lower section is not yet definitely known, however it is believed that the water will be considerably clearer because of the removal of silt in the upstream sections. The clarification and storage of the waters will be conducive to increased algal growths and may produce taste and odor problems which will be more difficult to deal with than the silt has been. If a definite minimum flow can be assured in the river at all time, this fact will be of great value to the cities in the lower reaches in determining their sanitary needs.

Need for Treatment Works

A summary of sources of pollution and sewage treatment needs is shown in Tables 11 and 12. An analysis of the data indicates that 106 new plants are needed and that 98 plants now in existence are in need of improvements. There are 236 municipalities in the Basin which now have some form of sewage treatment works. The status of the remaining 238 communities has not definitely been determined, therefore their needs have not been classified in this report. Most of these communities are small. The latter group of towns average approximately 500 in population and will undoubtedly need treatment works at some future date if none are in existence at the present. It is estimated that the sewage treatment plants and improvements needed in the near future will cost $27,000,000 and that at least an additional $6,500,000 will be needed for facilities in those communities which have not yet been classified. The cost figures cited will undoubtedly be revised upward on receipt of additional information. It is extremely difficult to evaluate the status of the industrial operations, however, there are 15 or more communities in which industry contributes substantially more waste than the domestic population. It is believed that the industry in 8 communities will find it necessary to construct primary treatment works. Improvements will be required at one industrial waste treating plant already in existence. The status of 6 industries not now having waste treatment is unknown, and it has not been determined whether 2 of the 3 industrial operations where treatment is now in existence is satisfactory to meet all requirements. It is probable that the cost of plants needed to treat industrial wastes will surpass the $5,000,000 mark.

TABLE 11

LOWER MISSOURI RIVER SUB-DIVISION

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	580	1,421,312	1,145,000
Industrial Plants b/	15	---	*1,323,800 (Est.)
Total	595	1,421,312	2,246,800

* Industry remote from municipal sewers.

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the non-similar wastes in terms of a common unit, Population Equivalent.

TABLE 12

LOWER MISSOURI RIVER SUB-DIVISION

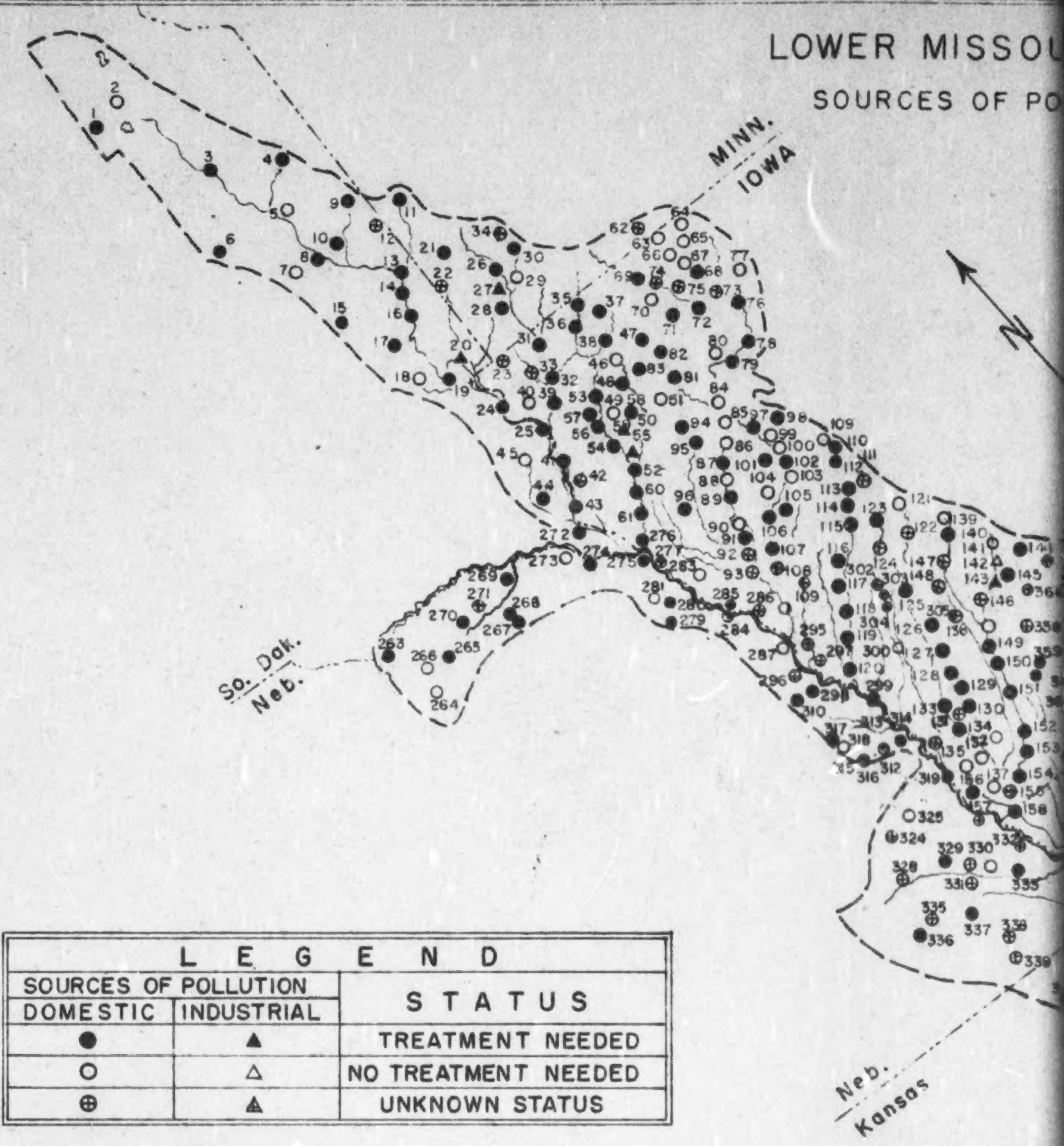
Sewage and Industrial Waste Treatment Plant Requirements

		Without Treatment			With Treatment				
Source (1)	Total No. (2)	No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)	No Project Req'd (9)	No Data (10)
Municipalities	580	106	106	0	236	98	26	112	*238
Industrial Plants	15	8	8	4	3	1	2		
Total	595	114	114	4	239	99	28	112	238

* Insufficient data.

LOWER MISSOU

SOURCES OF PO



MINN.
IOWA
N
So. Dak.
Neb.
Neb.
Kansas

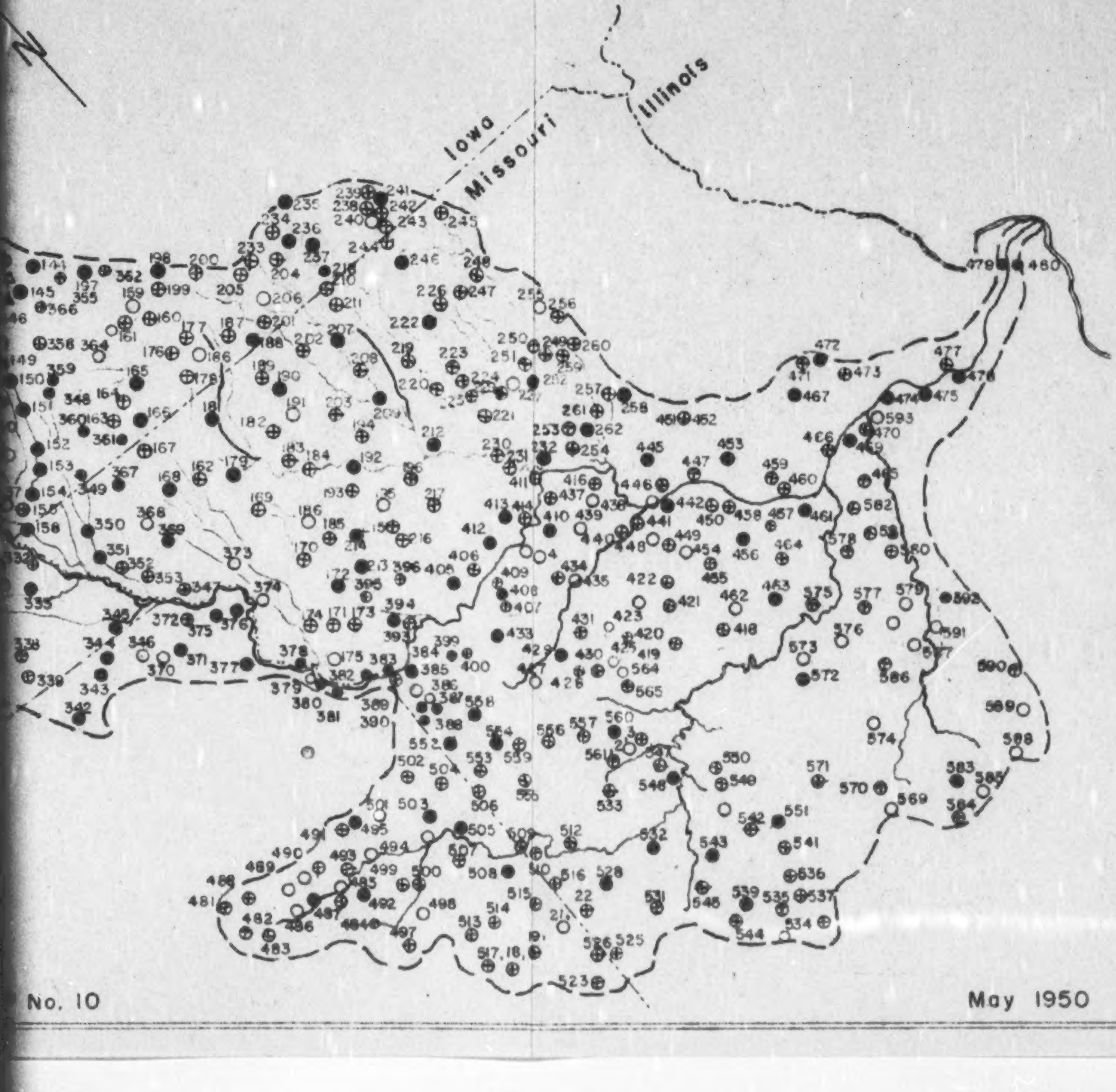
LEGEND		
SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	▲	UNKNOWN STATUS

See pages ~~60~~ 48 to ~~73~~ 54 for names of Sources of Pollution.

MAP No.

SOURI BASIN

F POLLUTION


Iowa
Missouri
Illinois

No. 10

May 1950

KEY TO MAP SHOWING SOURCES OF POLLUTION IN THE LOWER MISSOURI SUB-DIVISION

1. Webster, S. D.
2. Waubay, S. D.
3. Watertown, S. D.
4. Clear Lake, S. D.
5. Estelline, S. D.
6. Lake Preston, S. D.
7. Arlington, S. D.
8. Volga, S. D.
9. White, S. D.
10. Brookings, S. D.
11. Lake Benton, Minn.
12. Elkton, S. D.
13. Flandreau, S. D.
14. Flandreau Indian School
15. Madison, S. D.
16. Dell Rapids, S. D.
17. Humboldt, S. D.
18. Hartford, S. D.
19. Sioux Falls, S. D.
20. Sioux Falls, S.D. (Industrial)
21. Pipestone, Minn.
22. Jasper, Minn.
23. Larchwood, Iowa
24. Canton, S. D.
25. Hudson, S. D.
26. Edgerton, Minn.
27. Rendering Works
28. Luverna, Minn.
29. Adrian, Minn.
30. Ellsworth, Minn.
31. Rock Rapids, Iowa
32. Doon, Iowa
33. Alvord, Iowa
34. Rushmore, Minn.
35. Little Rock, Iowa
36. George, Iowa
37. Sibley, Iowa
38. Ashton, Iowa
39. Rock Valley, Iowa
40. Inwood, Iowa
41. Hawarden, Iowa
42. Ireton, Iowa
43. Akron, Iowa
44. Beresford, S. D.
45. Alcester, S. D.
46. Sheldon, Iowa
47. Sanborn, Iowa
48. Hospers, Iowa
49. Alton, Iowa
50. Remsen, Iowa
51. Granville, Iowa
52. LeMars, Iowa
53. Boyden, Iowa
54. Hull, Iowa
55. Hull, Iowa (Industrial)
56. Sioux City, Iowa
57. Maurice, Iowa
58. Orange City, Iowa
59. Orange City, Iowa (Industrial)
60. Merrill, Iowa
61. Hinton, Iowa
62. Round Lake, Minn.
63. Lake Park, Iowa
64. Orleans, Iowa
65. Spirit Lake, Iowa
66. Okoboji, Iowa
67. Arnold's Park, Iowa
68. Milford, Iowa
69. Ocheyedan, Iowa
70. Harris, Iowa
71. Hartley, Iowa
72. Everly, Iowa
73. Spencer, Iowa
74. Superior, Iowa
75. Terrill, Iowa
76. Royal, Iowa
77. Ruthven, Iowa
78. Sioux Rapids, Iowa
79. Linn Grove, Iowa
80. Peterson, Iowa

81. Sutherland, Iowa
82. Primghar, Iowa
83. Paullina, Iowa
84. Cherokee, Iowa
85. Cherokee State Hospital
86. Quimby, Iowa
87. Washta, Iowa
88. Pierson, Iowa
89. Correctionville, Iowa
90. Cushing, Iowa
91. Anthon, Iowa
92. Otto, Iowa
93. Smithland, Iowa
94. Marcus, Iowa
95. Kingsley, Iowa
96. Moville, Iowa
97. Aurelia, Iowa
98. Alta, Iowa
99. Schaller, Iowa
100. Galva, Iowa
101. Odebolt, Iowa
102. Arthur, Iowa
103. Ida Grove, Iowa
104. Holstein, Iowa
105. Battle Creek, Iowa
106. Danburg, Iowa
107. Mapleton, Iowa
108. Castana, Iowa
109. Little Sioux, Iowa
110. Early, Iowa
111. Wall Lake, Iowa
112. Arcadia, Iowa
113. Westside, Iowa
114. Vail, Iowa
115. Denison, Iowa
116. Dow City, Iowa
117. Dunlap, Iowa
118. Woodbine, Iowa
119. Logan, Iowa
120. Missouri Valley, Iowa
121. Manning, Iowa
122. Irwin, Iowa
123. Manilla, Iowa
124. Defiance, Iowa
125. Harlan, Iowa
126. Avoca, Iowa
127. Hancock, Iowa
128. Oakland, Iowa
129. Oakland, Iowa (Industrial)
130. Carson, Iowa
131. Macedonia, Iowa
132. Emerson, Iowa
133. Shelby, Iowa
134. Malvern, Iowa
135. Randolph, Iowa
136. Walnut, Iowa
137. Sidney, Iowa
138. Audubon Cannery
139. Audubon, Iowa
140. Exira, Iowa
141. Atlantic, Iowa
142. Cannery
143. Atlantic, Iowa (Industrial)
144. Adair, Iowa
145. Anita, Iowa
146. Lewis, Iowa
147. Kimballton, Iowa
148. Elk Horn, Iowa
149. Griswold, Iowa
150. Elliott, Iowa
151. Red Oak, Iowa
152. Essex, Iowa
153. Shenandoah, Iowa
154. Farragut, Iowa
155. Riverton, Iowa
156. Tabor, Iowa
157. Thurman, Iowa
158. Hamburg, Iowa
159. Creston, Iowa
160. Blockton, Iowa
161. Clearfield, Iowa
162. Conception Junction, Mo.
163. New Market, Iowa
164. Gravity, Iowa
165. Lennox, Iowa
166. Bedford, Iowa
167. Hopkins, Mo.
168. Maryville, Mo.
169. King City, Mo.
170. Stewartsville, Mo.

171. Edgerton, Mo.
172. Plattsburg, Mo.
173. Smithville, Mo.
174. Dearborn, Mo.
175. Platte City, Mo.
176. Diagonal, Iowa
177. Tingley, Iowa
178. Benton, Iowa
179. Stanberry, Mo.
180. Mt. Ayr, Iowa
181. Grant City, Mo.
182. New Hampton, Mo.
183. McFall, Mo.
184. Pattonsburg, Mo.
185. Osborn, Mo.
186. Maysville, Mo.
187. Kellerton, Iowa
188. Lamoni, Iowa
189. Eagleville, Mo.
190. Ridgeway, Mo.
191. Bethany, Mo.
192. Gallatin, Mo.
193. Winston, Mo.
194. Jamesport, Mo.
195. Hamilton, Mo.
196. Breckenridge, Mo.
197. Greenfield, Iowa
198. Afton, Iowa
199. Lorimor, Iowa
200. Murray, Iowa
201. Davis City, Iowa
202. Cainesville, Mo.
203. Gilman City, Mo.
204. Garden Grove, Iowa
205. Van Wert, Iowa
206. Leon, Iowa
207. Princeton, Mo.
208. Spickardsville, Mo.
209. Trenton, Mo.
210. Lineville, Iowa
211. Mercer, Mo.
212. Chillicothe, Mo.
213. Lathrop, Mo.
214. Cameron, Mo.
215. Kingston, Mo.
216. Cowgill, Mo.
217. Braymer, Mo.
218. Allerton, Iowa
219. Galt, Mo.
220. Chula, Mo.
221. Meadville, Mo.
222. Milan, Mo.
223. Browning, Mo.
224. Purdin, Mo.
225. Linneus, Mo.
226. Green City, Mo.
227. Brookfield, Mo.
228. Marceline, Mo.
229. Laclede, Mo.
230. Hale, Mo.
231. Bosworth, Mo.
232. Brunswick, Mo.
233. Weldon, Iowa
234. Derby, Iowa
235. Chariton, Iowa
236. Humeston, Iowa
237. Corydon, Iowa
238. Mystic, Iowa
239. Rathbun, Iowa
240. Seymour, Iowa
241. Centerville, Iowa
242. Numa, Iowa
243. Exline, Iowa
244. Cincinnati, Iowa
245. Glenwood, Mo.
246. Unionville, Mo.
247. Greencastle, Mo.
248. Novinger, Mo.
249. New Cambria, Mo.
250. Ethel, Mo.
251. Bucklin, Mo.
252. Marceline, Mo.
253. Keytesville, Mo.
254. Dalton, Mo.
255. LaPlata, Mo.
256. Atlanta, Mo.
257. Huntsville, Mo.
258. Moberly, Mo.
259. Bevier, Mo.
260. Callao, Mo.

261. Clifton Hill, Mo.
262. Salisbury, Mo.
263. Niobrara, Nebr.
264. Creighton, Nebr.
265. Bloomfield, Nebr.
266. Center, Nebr.
267. Coleridge, Nebr.
268. Hartington, Nebr.
269. Wynot, Nebr.
270. Crofton, Nebr.
271. Fordyce, Nebr.
272. Elk Point, S. D.
273. Newcastle, Nebr.
274. Ponca, Nebr.
275. South Sioux City, Nebr.
276. Sioux City, Iowa
277. Dakota City, Nebr.
278. Sioux City Air Base
279. Walthill, Nebr.
280. Winnebago, Nebr.
281. Indian Hospital, Nebr.
282. Salix, Iowa
283. Sloan, Iowa
284. Decatur, Nebr.
285. Onawa, Iowa
286. Blencoe, Iowa
287. Tekameh, Nebr.
288. Schleswig, Iowa
289. Charter Oak, Iowa
290. Ricketts, Iowa
291. Ute, Iowa
292. Soldier, Iowa
293. Moorhead, Iowa
294. Pisgah, Iowa
295. Mondamin, Iowa
296. Herman, Nebr.
297. Modale, Iowa
298. Blair, Nebr.
299. Carter Lake, Iowa
300. Omaha, Nebr.
301. Council Bluffs, Iowa
302. Earling, Iowa
303. Panama, Iowa
304. Portsmouth, Iowa
305. Persia, Iowa
306. Neola, Iowa
307. Underwood, Iowa
308. Iowa School for Deaf
309. Bellevue, Nebr.
310. Kennard, Nebr.
311. Ralston, Nebr.
312. Stock Yards, Omaha, Nebr.
313. Omaha, Nebr. (Industrial)
314. Ft. Crook, Nebr.
315. Millard, Nebr.
316. Papillion, Nebr.
317. Elkhorn, Nebr.
318. Boys Town, Nebr.
319. Plattsmouth, Nebr.
320. Rendering Plant, Iowa
321. Glenwood, Iowa
322. Glenwood State School, Iowa
323. Packing Plant, Iowa
324. Elmwood, Nebr.
325. Weeping Water, Nebr.
326. Nebraska City, Nebr.
327. Peru, Nebr.
328. Palmyra, Nebr.
329. Syracuse, Nebr.
330. Talmage, Nebr.
331. Cook, Nebr.
332. Brock, Nebr.
333. Auburn, Nebr.
334. Rockport, Mo.
335. Sterling, Nebr.
336. Adams, Nebr.
337. Tecumseh, Nebr.
338. Table Rock, Nebr.
339. Pawnee City, Nebr.
340. Humboldt, Nebr.
341. Dawson, Nebr.
342. Seneca, Kansas
343. Sabetha, Kansas
344. Falls City, Nebr.
345. Morrill, Kansas
346. Hiawatha, Kansas
347. Oregon, Mo.
348. Stanton, Iowa
349. Coin, Iowa
350. Tarkio, Mo.

351. Fairfax, Mo.
352. Craig, Mo.
353. Mound City, Mo.
354. Adair, Iowa
355. Anita, Iowa
356. Massena, Iowa
357. Fontanelle, Iowa
358. Carbon, Iowa
359. Villisca, Iowa
360. Clarinda State Hospital, Iowa
361. Clarinda, Iowa
362. Orient, Iowa
363. Prescott, Iowa
364. Corning, Iowa
365. Corning, Iowa (Industrial)
366. Nodaway, Iowa
367. Burlington Junction, Mo.
368. Skidmore, Mo.
369. Maitland, Mo.
370. Hiawatha, Kansas
371. Robinson, Kansas
372. Highland, Kansas
373. Savannah, Mo.
374. St. Joseph, Mo.
375. Troy, Kansas
376. Wathena, Kansas
377. Atchinson, Kansas
378. Weston, Mo.
379. Ft. Leavenworth, Kansas
380. Leavenworth, Kansas
381. State Pen.-Lansing, Kansas
382. Parkville, Mo.
383. North Kansas City, Mo.
384. Kansas City, Mo.
385. Lenexa, Mo.
386. Kansas City Suburban Areas
387. Kansas City, Mo. (Industrial)
388. Kansas City, Mo. (Industrial)
389. Jackson County Girls' School
390. Lee's Summit, Mo.
391. Unity Farms, Mo.
392. Liberty, Mo.
393. Missouri City, Mo.
394. Excelsior Springs, Mo.
395. Holt, Mo.
396. Kearney, Mo.
397. Orrick, Mo.
398. Camden, Mo.
399. Grain Valley, Mo.
400. Oak Grove, Mo.
401. Wellington, Mo.
402. Henrietta, Mo.
403. Lexington, Mo.
404. Lawson, Mo.
405. Richmond, Mo.
406. Hardin, Mo.
407. Mayview, Mo.
408. Higginsville, Mo.
409. Carder, Mo.
410. Waverly, Mo.
411. Miami, Mo.
412. Norborne, Mo.
413. Carrollton, Mo.
414. Wanenda, Mo.
415. DeWitt, Mo.
416. Gilliam, Mo.
417. Glasgow, Mo.
418. Stover, Mo.
419. Windsor, Mo.
420. Green Ridge, Mo.
421. Smithton, Mo.
422. Otterville, Mo.
423. Sedalia, Mo.
424. Pilot Grove, Mo.
425. Houston, Mo.
426. Holden, Mo.
427.
428. Chilhowee, Mo.
429. Warrensburg, Mo.
430. Leeton, Mo.
431. Knobnoster, Mo.
432. Concordia, Mo.
433. Odessa, Mo.
434. Blackburn, Mo.
435. Sweet Springs, Mo.
436. Alma, Mo.
437. Malta Bend, Mo.
438. Slater, Mo.
439. Marshall, Mo.
440. Nelson, Mo.

441. Blackwater, Mo.
442. Boonville, Mo.
443. Higbee, Mo.
444. Fayette, Mo.
445. New Franklin, Mo.
446. Franklin, Mo.
447. Rocheport, Mo.
448. Pilot Grove, Mo.
449. Bunceton, Mo.
450. Prairie Home, Mo.
451. Clark, Mo.
452. Sturgeon, Mo.
453. Columbia, Mo.
454. Tipton, Mo.
455. Clarksburg, Mo.
456. California, Mo.
457. Centertown, Mo.
458. Jamestown, Mo.
459. Ashland, Mo.
460. Industrial
461. Jefferson City, Mo.
462. Versailles, Mo.
463. Eldon, Mo.
464. Russellville, Mo.
465. Linn, Mo.
466. Mokane, Mo.
467. Auxvasse, Mo.
468. Fulton, Mo.
469. Chamois, Mo.
470. Morrison, Mo.
471. Martinsburg, Mo.
472. Wellsville, Mo.
473. New Florence, Mo.
474. Hermann, Mo.
475. New Haven, Mo.
476. Gerald, Mo.
477. Marthasville, Mo.
478. Washington, Mo.
479. St. Charles, Mo.
480. St. Louis, Mo.
481. Eskridge, Kansas
482. Admire, Kansas
483. Reading, Kansas
484. Malvern, Kansas
485. Quenemo, Kansas
486. Osage City, Kansas
487. Lyndon, Kansas
488. Harveyville, Kansas
489. Burlingame, Kansas
490. Scranton, Kansas
491. Carbondale, Kansas
492. Williamsburg, Kansas
493. Pomona, Kansas
494. Ottawa, Kansas
495. Baldwin City, Kansas
496. Osawatomie, Kansas
497. Westphalia, Kansas
498. Garnett, Kansas
499. Richmond, Kansas
500. Greeley, Kansas
501. Wellsville, Kansas
502. Spring Hill, Kansas
503. Paola, Kansas
504. Louisburg, Kansas
505. LaCygne, Kansas
506. Drexel, Mo.
507. Parker, Kansas
508. Pleasanton, Kansas
509. Amoret, Mo.
510. Foster, Mo.
511. Butler, Mo.
512. Rich Hill, Mo.
513. Kincaid, Kansas
514. Blue Mound, Kansas
515. Fulton, Kansas
516. Hume, Mo.
517. Moran, Kansas
518. Bronson, Kansas
519. Uniontown, Kansas
520. Hepler, Kansas
521. Fort Scott, Kansas
522. Deerfield, Kansas
523. Arma, Kansas
524. Mulberry, Kansas
525. Liberal, Mo.
526. Arcadia, Kansas
527. Nevada, Mo.
528. State Hospital #3, Mo.
529. Schell City, Mo.
530. Rockville, Mo.

531. Sheldon, Mo.
532. El Dorado Springs, Mo.
533. Appleton City, Mo.
534. Miller, Mo.
535. Everton, Mo.
536. Republic, Mo.
537. Ash Grove, Mo.
538. Walnut Grove, Mo.
539. Greenfield, Mo.
540. Springfield, Mo.
541. Morrisville, Mo.
542. Fair Play, Mo.
543. Stockton, Mo.
544. Lockwood, Mo.
545. Jerico Springs, Mo.
546. Humansville, Mo.
547. Lowry City, Mo.
548. Osceola, Mo.
549. Weaubleau, Mo.
550. Wheatland, Mo.
551. Bolivar, Mo.
552. Bolton, Mo.
553. Freeman, Mo.
554. Harrisonville, Mo.
555. Adrian, Mo.
556. Creighton, Mo.
557. Urich, Mo.
558. Pleasant Hill, Mo.
559. Garden City, Mo.
560. Clinton, Mo.
561. Montrose, Mo.
562. Deepwater, Mo.
563. Brownington, Mo.
564. Windsor, Mo.
565. Calhoun, Mo.
566. Lincoln, Mo.
567. Warsaw, Mo.
568. Cole Camp, Mo.
569. Marshfield, Mo.
570. Niangua, Mo.
571. Buffalo, Mo.
572. Camdenton, Mo.
573. Linn Creek, Mo.
574. Lebanon, Mo.
575. Tuscumbia, Mo.
576. Crocker, Mo.
577. Iberia, Mo.
578. Meta, Mo.
579. Dixon, Mo.
580. Vienna, Mo.
581. Freeburg, Mo.
582. Westphalia, Mo.
583. Hartville, Mo.
584. Mansfield, Mo.
585. Mountain Grove, Mo.
586. Richland, Mo.
587. Waynesville, Mo.
588. Cabool, Mo.
589. Houston, Mo.
590. Licking, Mo.
591. Fort Leonard Wood, Mo.
592. Newburg, Mo.
593. Gasconade, Mo.

LOWER M

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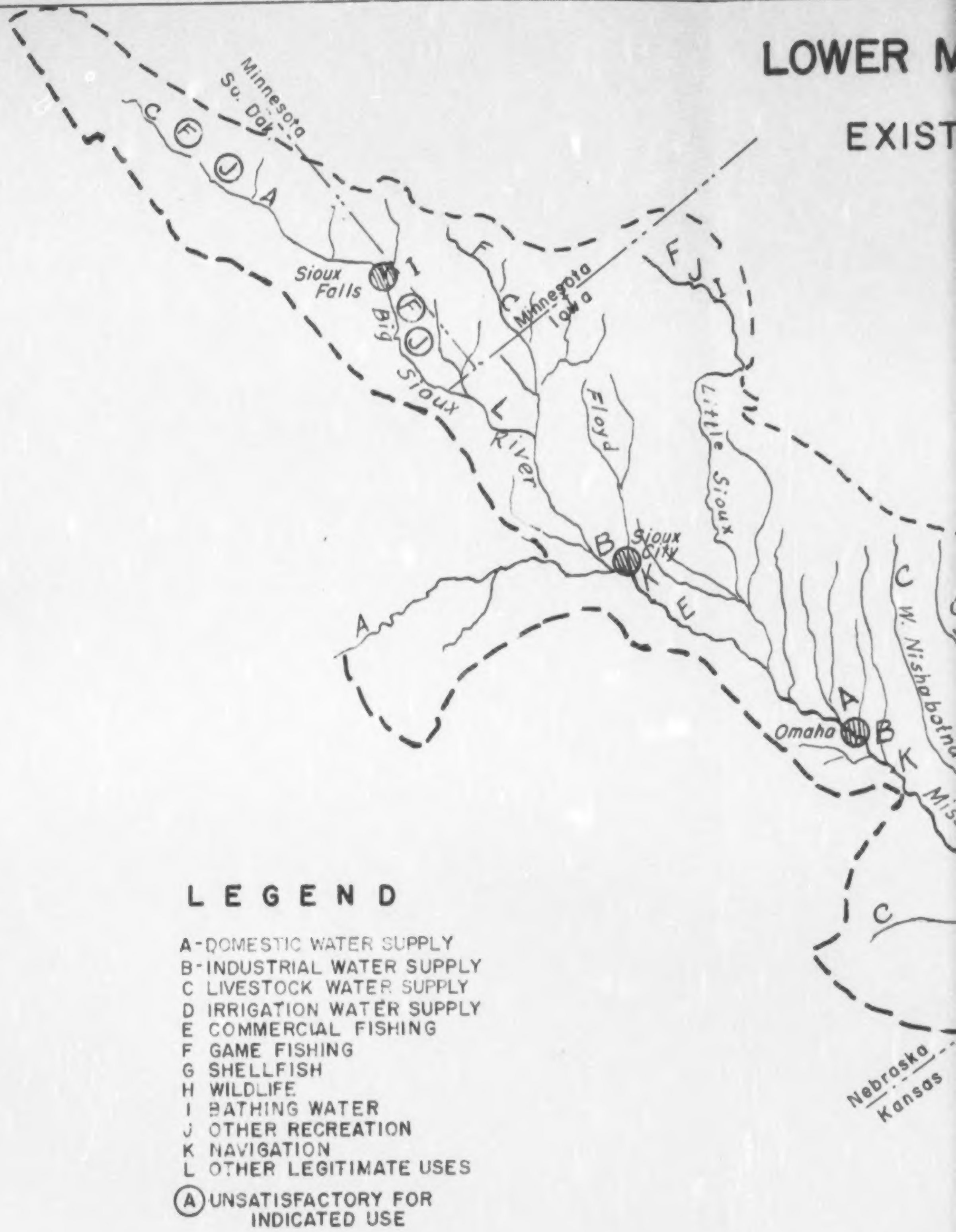
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A
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J
Big Sioux River
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Little Sioux
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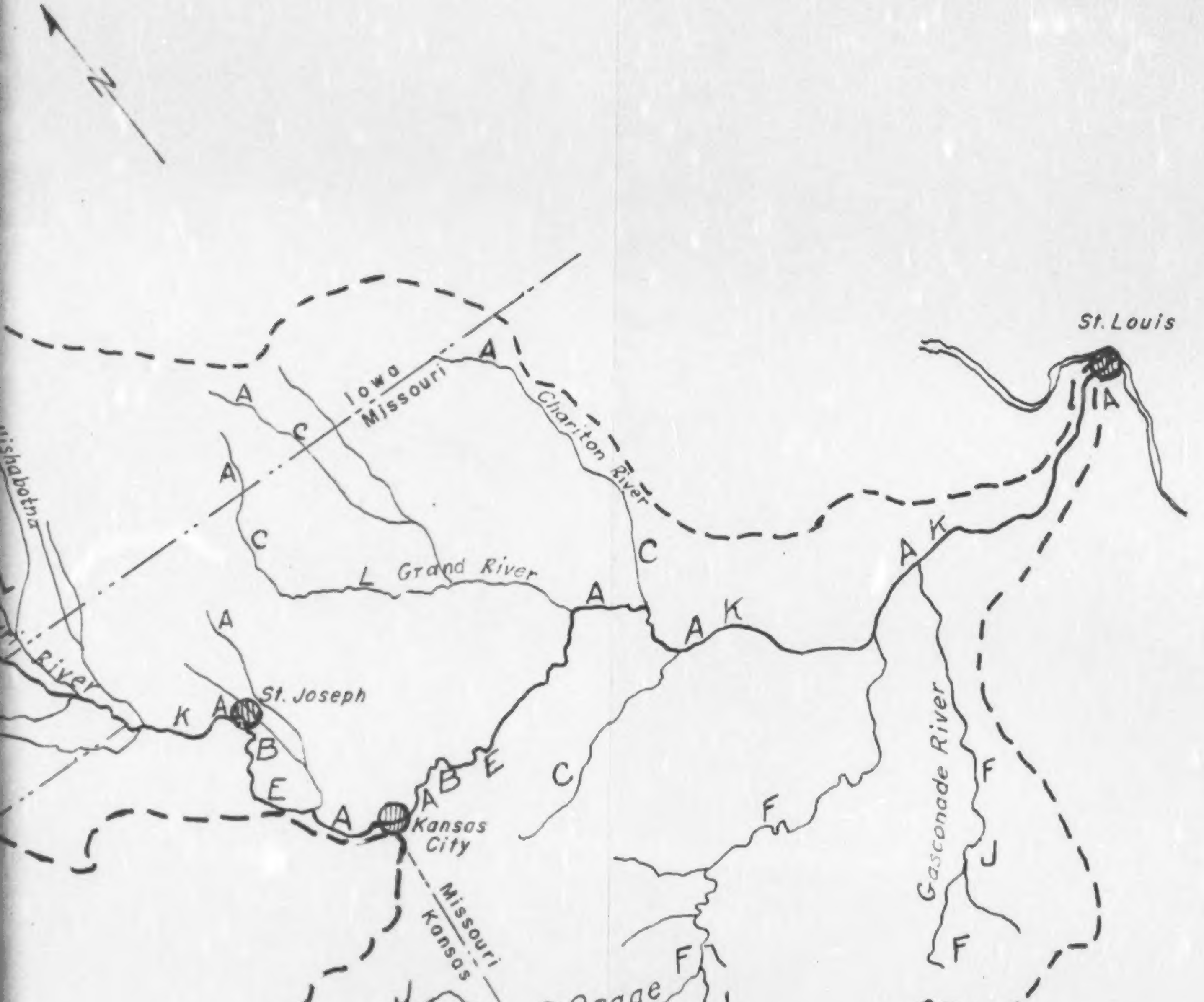
W. Nishabotna
A
Omaha
B
K
Mis
C
Nebraska
Kansas
LEGEND
A-DOMESTIC WATER SUPPLY
B-INDUSTRIAL WATER SUPPLY
C LIVESTOCK WATER SUPPLY
D IRRIGATION WATER SUPPLY
E COMMERCIAL FISHING
F GAME FISHING
G SHELLFISH
H WILDLIFE
I BATHING WATER
J OTHER RECREATION
K NAVIGATION
L OTHER LEGITIMATE USES
Ⓐ UNSATISFACTORY FOR INDICATED USE

MA

ISSOURI SUB-DIVISION

NG WATER USES



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Gasconade River
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No. 11

MAY 1950

FORT PECK TO SIOUX CITY SUB-DIVISION

Description of Sub-Division

The Fort Peck to Sioux City Sub-division includes the main stem of the Missouri River and that land lying north and east of the River which will ultimately be affected by development of the water resources of the Missouri River Basin. Approximately 75,000 square miles of the States of Montana, North and South Dakota are included in this Sub-division. Very little water is contributed to the main stem from runoff in this area. The annual discharge of the Missouri River at Sioux City, Iowa, above the confluence with the Big Sioux River, is 14,600,000 acre-feet. The Missouri's major contributor from within this Sub-division is the James River, which discharges approximately 40,000 acre-feet annually. The waters of the main stem contain a considerable amount of silt throughout this stretch of the river, most of which originates in the Yellowstone Sub-Basin. Chemical characteristics of the river water are such that it is readily usable for municipal and domestic needs, and is excellent for irrigation pruposes. The waters of the James River are somewhat less satisfactory for these uses because of rather high salt content. The main stem of the Missouri River flows through this Sub-division in a generally southeasterly direction for a distance of about 1,300 miles, with an average stream gradient of 1.2 feet per mile. The James River, approximately 700 miles in length, virtually parallels the Missouri River for most of its length before it joins the Missouri near Yankton, South Dakota. The gradient of the James River is very flat, averaging only about 0.25 of a foot per mile. Flows in the James are extremely erratic, a condition which is due to the climatic conditions and the topography of the region.

Rainfall varies from 12 inches annually in the northwestern section of this Sub-division, to 26 inches annually in the extreme southeastern section. Most of the extremely limited rainfall in the northwestern section occurs during the months of March, April, and May, and therefore is generally available for the growing of crops. The large expanses of level land and absorptive soils hold runoff to an absolute minimum. The climate is a rigorous one having a mean annual temperature of 43° F.; recorded extreme temperatures are a minimum of -42° and a maximum of 118°. The humidity is relatively low throughout the entire Sub-division but increases somewhat in the southeastern extremity. Precipitation is usually the result of storms entering the region from the Hudson Bay area and traveling in a generally southeasterly direction across the Sub-division. Moisture from the Gulf of Mexico occasionally reaches this area but it is not the dominant source of moisture.

Most of the Sub-division is in the glaciated Missouri plateau and has extremely deep soils. The elevations of the region range from 2,000 feet at its extreme western boundary to slightly more than 1,000 feet at its southern and eastern terminus. The topography is that of a flat plain with numerous dunelike hills. The area lying between the Missouri River and the James River has no well-developed pattern of drainage and during periods of heavy precipitation is dotted with lakes and ponds. This topography is known locally as "pimple-dimple" land. This type of terrain is exemplified by the existence of the Devil's Lakes of North Dakota which do not have any natural drainage. The soils are generally deep glacial till and are high in natural fertility.

Ground water is readily available in considerable quantities along the bottom lands on either side of the Missouri River. Ground water, in small quantities and usually highly mineralized, can also be obtained over most of the Sub-division from shallow wells. Large volumes of ground water were at one time available from the geological formation known as the Dakota sandstone. In order to tap this source it was necessary to drill to depths greater than 1,000 feet. Water in the formation was originally under considerable pressure and flowing wells often resulted. So many of these wells were drilled in the early days that pressure within the formation was greatly reduced and most wells ceased to flow. It was necessary to inaugurate conservation practices to minimize further reduction of water levels. Water with the desirable characteristics for both irrigation and municipal use is therefore at a premium. Deposits of lignite and a small amount of building stone constitute the limited mineral wealth of this Sub-division.

There are no forests, and tree growth is limited largely to the flood plain along the main stem of the Missouri River. Recreational facilities are very limited. Fish propagation in the main stem or its tributaries have not met with success and further developments must await the construction of large reservoirs to free the streams of silt and the undesirable chemical constituents. Prior to 1900, Devil's lake region of North Dakota was a famous resort area and the lake teemed with fish and wild fowl. Since that time, however, this lake has gradually dried up and the mineral content of the water has increased to such a concentration that fish no longer survive.

In 1940, this Sub-division supported a population of 529,000 people; 75 percent resided in rural districts and the remainder in small cities and towns. The economy of the area rests largely upon its agricultural products. Dry farming in the past has dominated the entire region; however upon completion of the proposed Missouri Basin development program, in excess of 2 million acres of newly irrigated land will be located within this Sub-division.

Industry has been limited largely to that of processing of agricultural products. The rich soil of the region needs only water to make it highly productive for agricultural purposes and it is reasonable to expect that with an increase in intensive farming there will likewise be an increase in population and industrial development. The fullest development of the water resources is the key to the entire situation. With the proposed diversion of water from the Upper Missouri River and the construction of 4 additional reservoirs on the main stem between Sioux City and Fort Peck, the water needs of a wide part of the Sub-division will be substantially satisfied.

Important cities located within the Sub-division are Williston, Bismarck, and Jamestown, in North Dakota; Aberdeen, Huron, Mitchell, Yankton, and Pierre, in South Dakota. These cities, serviced by three railroad systems and a well-developed highway system, represent the trade centers for their respective areas. The cities in the Devil's Lake and James River regions will benefit most by the water resources development program. They will then have sufficient water for municipal, industrial, and sanitary uses. Recreational facilities for the region will be greatly increased. On the main stem, increased problems of municipal water supply and waste disposal may be experienced. Other public health problems may develop in this region due to the production of insects, primarily mosquitoes, as a result of the increased water use program. Some of these mosquitoes are known to be vectors of infectious encephalitis.

Sources of Pollution

There are 167 municipalities in the Fort Peck to Sioux City Sub-division having a population of more than 250 persons. Of this number 128 have sewers through which either treated or untreated wastes are contributed to streams. Map No. 12 illustrates sources of pollution. Sanitary sewers serve 212,400 persons and known industrial operations contribute a population equivalent of 19,700 persons for a total of 232,100 population equivalents. Approximately 35 percent of the biochemical oxygen demand of untreated waste is removed through treatment processes now in existence resulting in 171,000 population equivalents ultimately discharged to the waterways. The municipalities of this sub-division are relatively small in population, the largest cities being Minot and Bismarck, North Dakota; Aberdeen, Huron, Mitchell, and Yankton, in South Dakota. Bismarck, in North Dakota, and Yankton, in South Dakota discharge their wastes directly into the Missouri River. The small industrial waste population equivalent reflects the lack of industrial operations and insufficient data on the subject. It is quite likely that industrial development will increase when the water resources development program has been completed.

Water Use and Adequacy of Water for Those Uses

This Sub-division is potentially a very rich agricultural area. There frequently is insufficient moisture to develop the full productivity of the soils, consequently the economic status of this area is unstable. The poor chemical quality and the general absence of ground water in sufficient quantities has prevented ground water developments for other than very localized use. Surface water resources are virtually nonexistent except along the Missouri River. The proposed diversion of water from the Missouri River across North Dakota thence to the James and Cheyenne Rivers will provide much needed water for this region. One half of the land earmarked for irrigation under the Missouri River Development Plan is located within this Sub-division. The development of the water resources will be a boon to municipalities of the area, all of which are short of supply except those that derive their water directly from the Missouri River. Surface water is supplied to 79,375 persons and ground water to 135,354 persons. These municipal systems supply approximately 16½ million gallons per day at an estimated cost of $2,100,000 annually to consumers.

The disposal of sanitary and industrial wastes has also created a difficult problem because of insufficient flow in most of the streams to assimilate the waste, thus requiring an extremely high degree of treatment to prevent nuisance conditions. Industry has undoubtedly been retarded in this region because of the lack of water resources for either processing use or waste dilution. Recreational uses of the water resources is very limited and there is little or no game fishing. The establishment of lakes and regulated stream flow would be of great importance to the propagation of wild fowl such as ducks and geese.

The cost of diverting the water from the Missouri River for use over this wide area makes the water very valuable. All uses, therefore, must be taken into consideration in planning the allotment of water. It is believed that municipal needs for both domestic and sanitation purposes should rate high. Since it is to be expected that the population of this Sub-division will increase materially when the development program has been placed in operation, the future needs of municipalities for both domestic supply and for sanitation must be considered as potential consumers of the water to be delivered from the Missouri River.

Sewage Treatment Needs

A summary of sources of pollution and treatment needs is shown on Tables No. 13 and No. 14. The summary indicates that 45 new sewage treatment works are needed and that improvements to 25 existing plants are necessary. Industrial operations cannot now be properly evaluated. The status of 12 municipalities with treatment works is not known and insufficient data from 39 other municipalities is available, consequently no attempt at their classification is made. It is estimated that the sewage treatment plants and improvements needed immediately will cost $5,300,000 and that an additional $1,300,000 will be necessary to provide treatment for those places where sufficient information is not now available to determine their exact needs. These figures will undoubtedly be revised upward on receipt of additional information at the completion of studies now pending. Industrial waste treatment costs are not included in these figures.

TABLE 13

FORT PECK TO SIOUX CITY SUB-DIVISION

Amount of Pollution Contributed

Source	Number	Estimated No. of People Served c/	Pop. Equivalent of Wastes Discharged to Watercourse d/
Municipalities a/	128	212,386	151,662
Industrial Plants b/	2		20,000 (Est.)
Total	130	212,386	171,662

a/ Includes incorporated and unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers and other population centers. (Also includes industrial waste discharged through municipal systems.)

b/ Industries discharging wastes directly to watercourse.

c/ Latest estimated population served by sewer system.

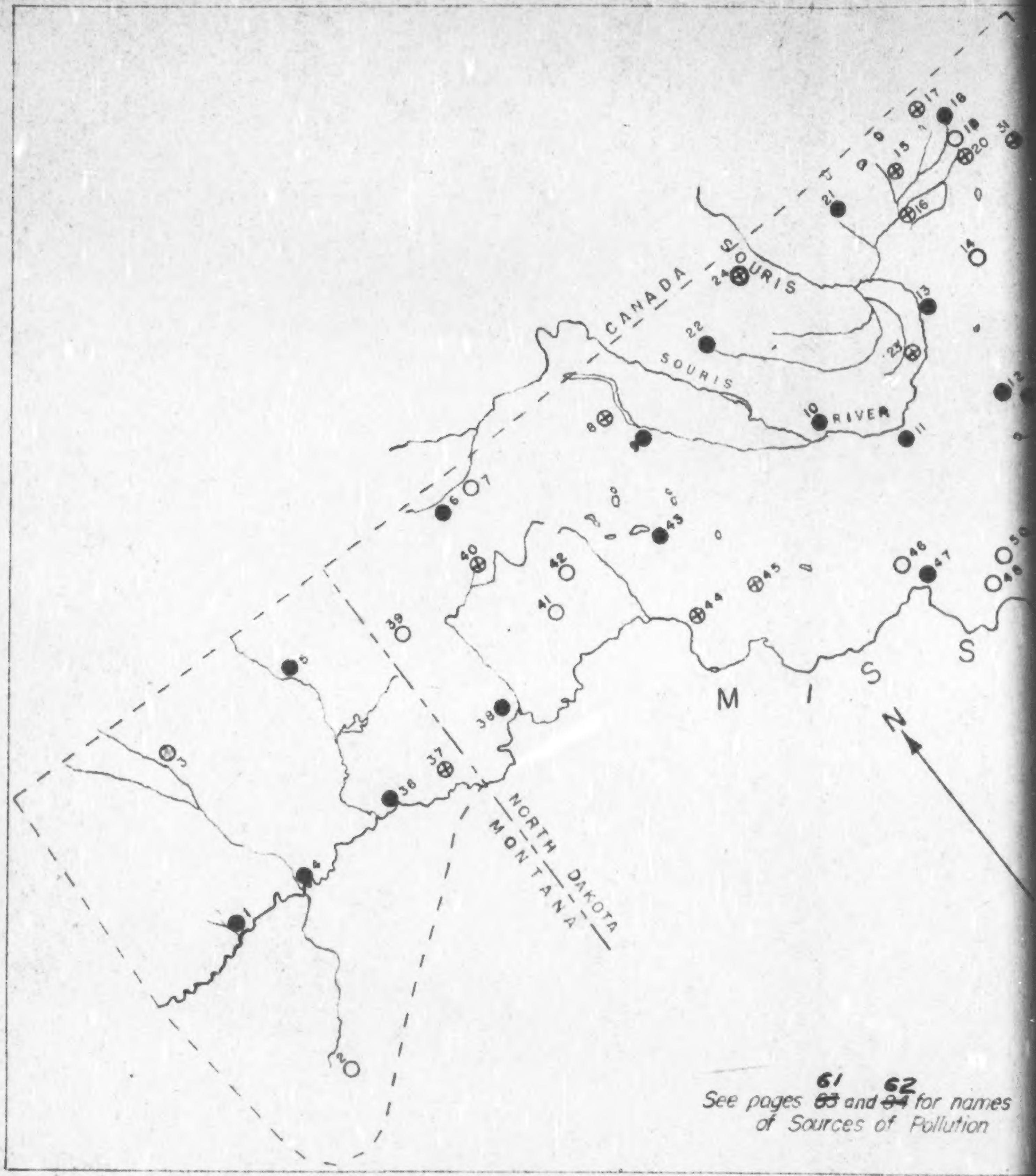
d/ In reducing to a common basis certain wastes from industries and municipalities, it is common practice to express the non-similar wastes in terms of a common unit, Population Equivalent.

TABLE 14

FORT PECK TO SIOUX CITY SUB-DIVISION

Sewage and Industrial Waste Treatment Plant Requirements

		Without Treatment			With Treatment				
Source (1)	Total No. (2)	No. (3)	Treatment Needed (4)	Status Unknown (5)	No. (6)	Improvements Req'd (7)	Status Unknown (8)	No Project Req'd (9)	No Data (10)
Municipalities	167	45	45	0	83	25	12	46	39
Industrial Plants	2	2	2						
Total	169	47	47	0	83	25	12	46	39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See pages 61 ~~63~~ and 62 ~~64~~ for names
of Sources of Pollution

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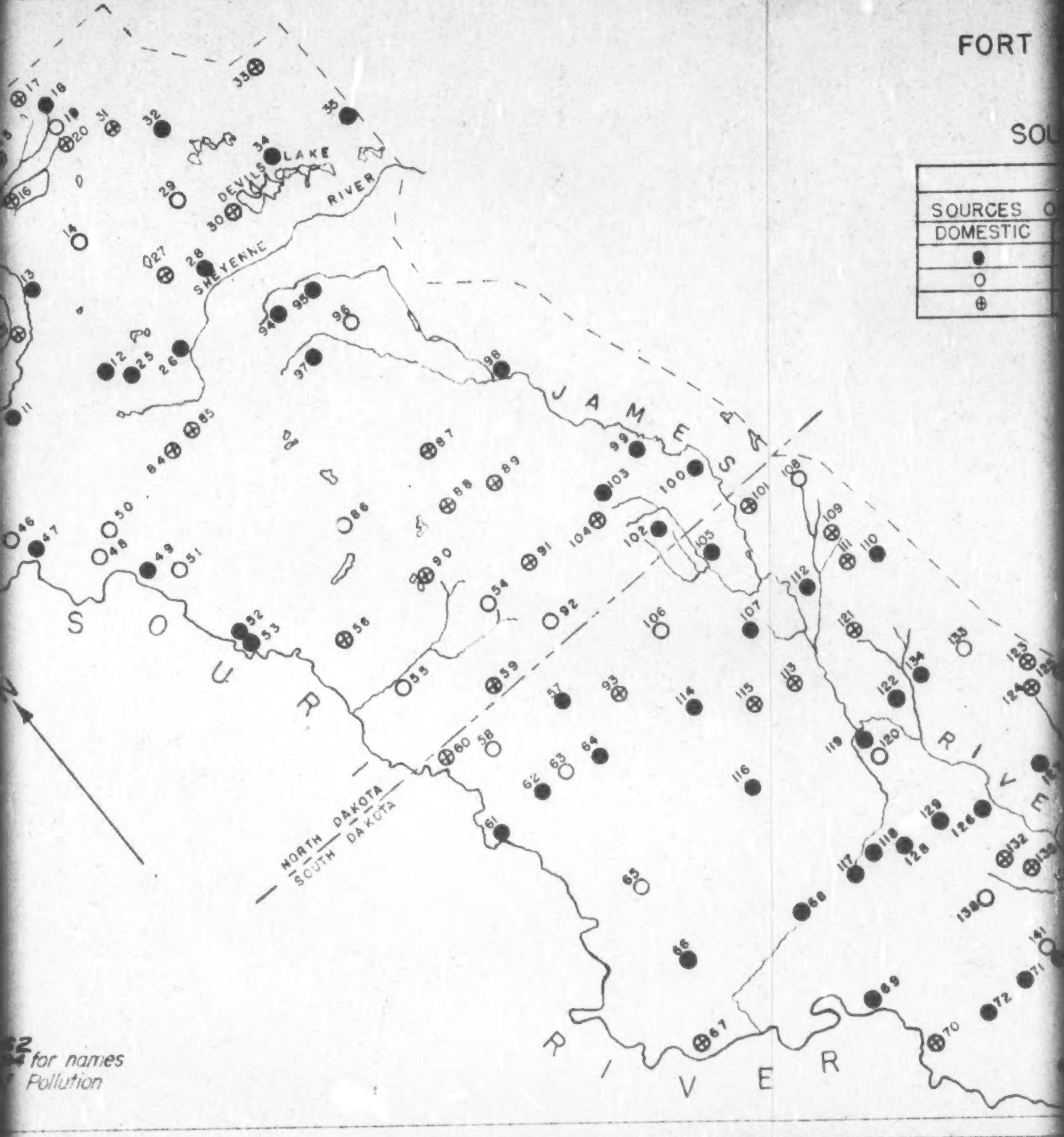

SOURCES O
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SHEYENNE RIVER
J A M E S R I V E
S O U R I V E R
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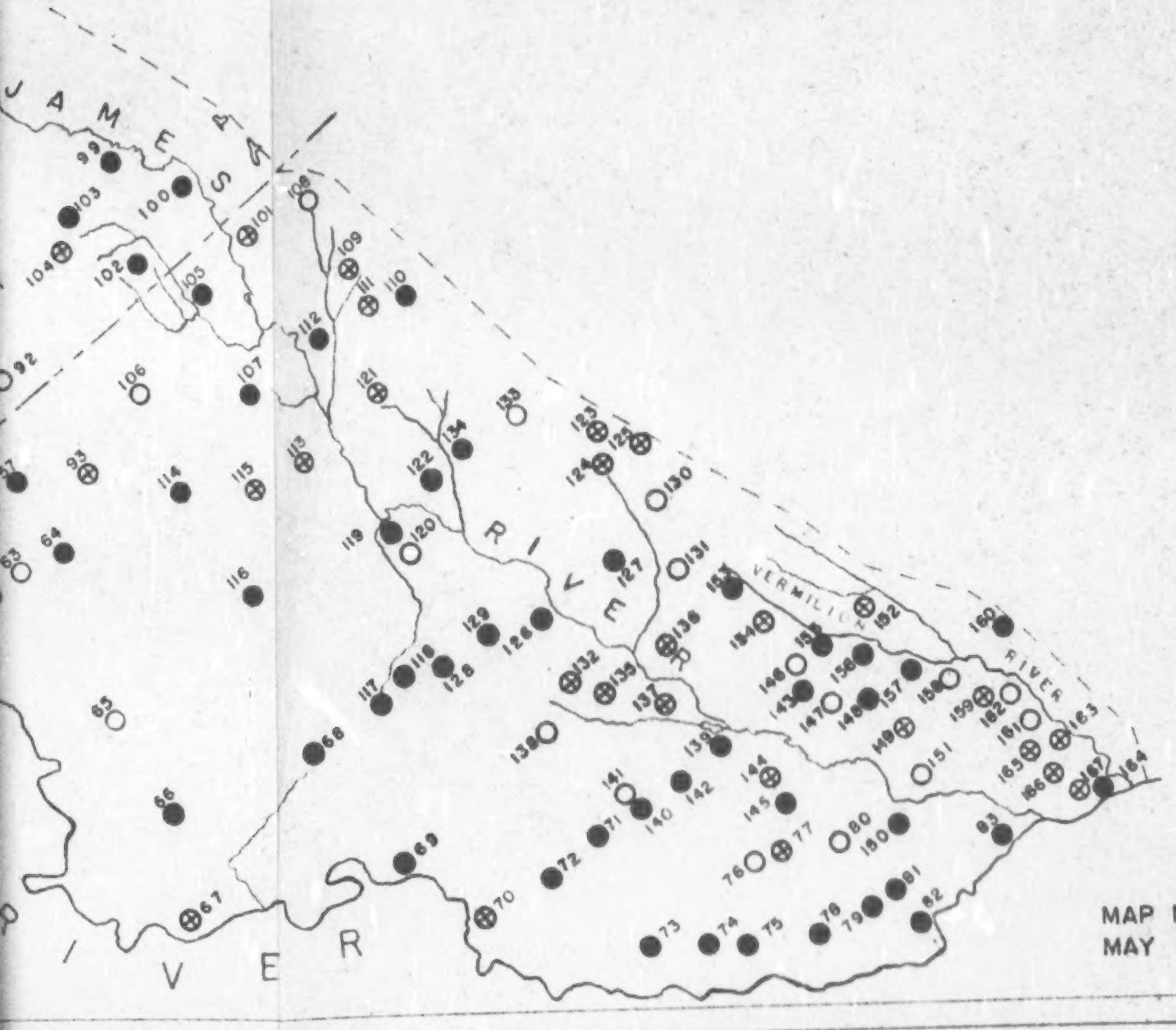
4 for names
Pollution

FORT PECK TO SIOUX CITY SUBDIVISION

SOURCES OF POLLUTION

LEGEND		
SOURCES OF POLLUTION		STATUS
DOMESTIC	INDUSTRIAL	
●	▲	TREATMENT NEEDED
○	△	NO TREATMENT NEEDED
⊕	▲	UNKNOWN STATUS


JAMES
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VERMILION
RIVER
RIVER
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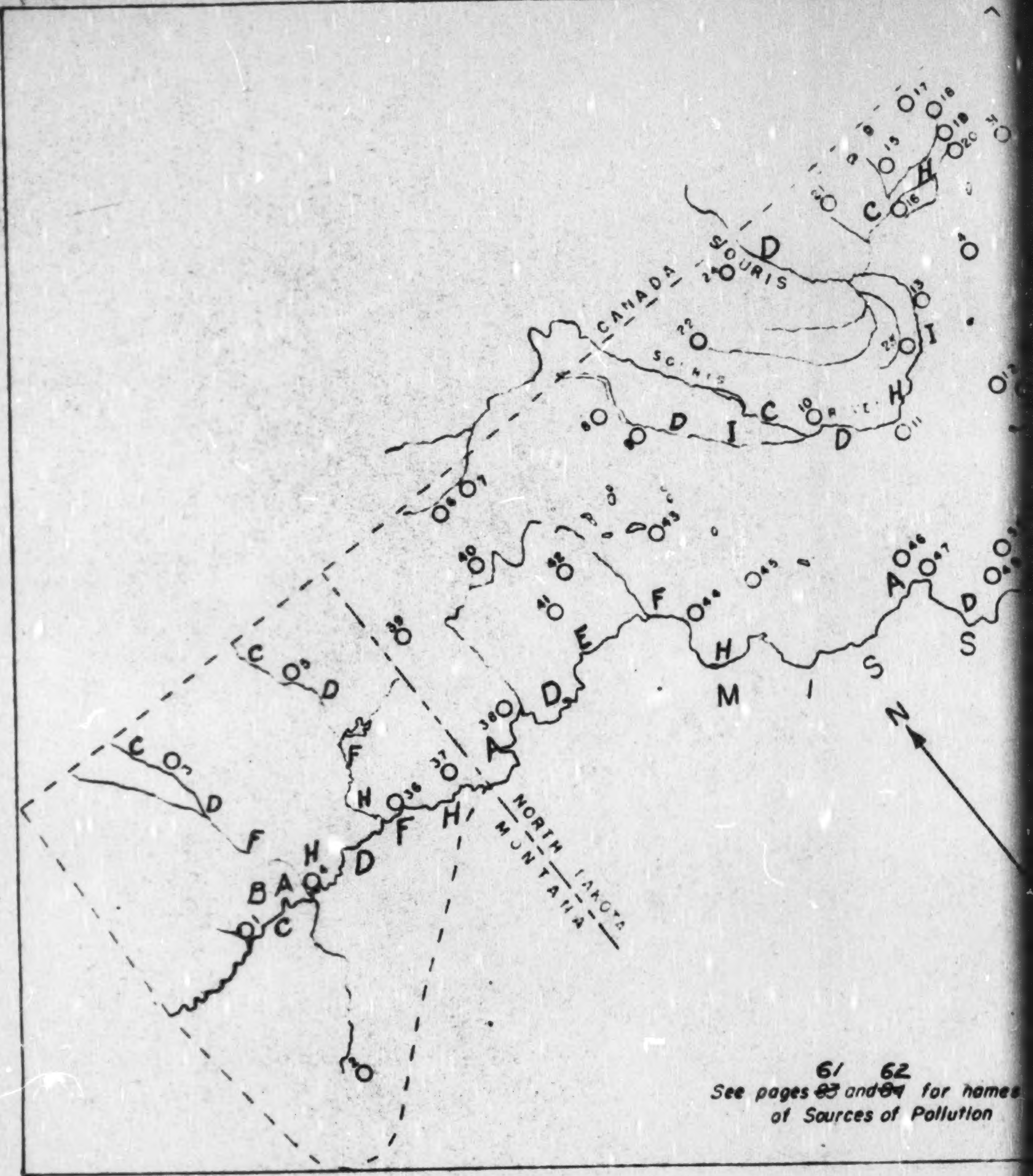
MAP NO. 12
MAY 1950

KEY TO MAP SHOWING SOURCES OF POLLUTION IN THE

FORT PECK TO SIOUX CITY SUB-DIVISION

1. Wolf Point, Mont.
2. Circle, Mont.
3. Scobey, Mont.
4. Popular, Mont.
5. Plentywood, Mont.
6. Crosby, N.D.
7. Noonan, N.D.
8. Bowbells, N.D.
9. Kenmare, N.D.
10. Minot, N.D.
11. Velva, N.D.
12. Drake, N.D.
13. Tower, N.D.
14. Rugley, N.D.
15. Dunseith, N.D.
16. Willow City, N.D.
17. St. John, N.D.
18. Rolla, N.D.
19. Belcourt, N.D.
20. Rolette, N.D.
21. Bottineau, N.D.
22. Monhall, N.D.
23. Granville, N.D.
24. Westhope, N.D.
25. Anamoose, N.D.
26. Harvey, N.D.
27. Esmond, N.D.
28. Maddock, N.D.
29. Leeds, N.D.
30. Minnewaukan, N.D.
31. Bisbee, N.D.
32. Cando, N.D.
33. Edmore, N.D.
34. Devils Lake, N.D.
35. Lakota, N.D.
36. Culbertson, Mont.
37. Bainville, Mont.
38. Williston, N.D.
39. Grenora, N.D.
40. Wildrose, N.D.
41. Ray, N.D.
42. Tioga, N.D.
43. Stanley, N.D.
44. Sanish, N.D.
45. Parshall, N.D.
46. Garrison, N.D.
47. Riverdale, N.D.
48. Underwood, N.D.
49. Washburn, N.D.
50. Turtle Lake, N.D.
51. Wilton, N.D.
52. Bismarck, N.D.
53. Fort Lincoln, N.D.
54. Wishek, N.D.
55. Linton, N.D.
56. Hazelton, N.D.
57. Eureka, S.D.
58. Herreid, S.D.
59. Zeeland, N.D.
60. Pollock, S.D.
61. Mobridge, S.D
62. Selby, S.D.
63. Java, S.D.
64. Bowdle, S.D.
65. Gettysburg, S.D.
66. Onida, S.D.
67. Pierre, S.D.
68. Highmore, S.D.
69. Ft. Thompson, S.D.
70. Chamberlain, S.D.
71. White Lake, S.D.
72. Kimball, S.D.
73. Platte, S.D.
74. Ceddes, S.D.
75. Lake Andes, S.D.
76. Armour, S.D.
77. Delmont, S.D.
78. Wagner, S.D.
79. Avon, S.D.
80. Tripp, S.D.

81. Tyndall, S.D.
82. Springfield, S.D.
83. Yankton, S.D.
84. McClusky, N.D.
85. Goodrich, N.D.
86. Steele, N.D.
87. Medina, N.D.
88. Streeter, N.D.
89. Gackle, N.D.
90. Napoleon, N.D.
91. Lehr, N.D.
92. Ashley, N.D.
93. Hosmer, S.D.
94. Fressenden, N.D.
95. New Rockford, N.D.
96. Carrington, N.D.
97. Sykeston, N.D.
98. Jamestown, N.D.
99. La Moure, N.D.
100. Oakes, N.D.
101. Hecla, S.D.
102. Ellendale, N.D.
103. Edgeley, N.D.
104. Kulm, N.D.
105. Frederick, S.D.
106. Leola, S.D.
107. Aberdeen, S.D.
108. Britton, S.D.
109. Pierpont, S.D.
110. Bristol, S.D.
111. Andover, S.D.
112. Groton, S.D.
113. Mellette, S.D.
114. Ipswich, S.D.
115. Cresbard, S.D.
116. Faulkton, S.D.
117. Miller, S.D.
118. St. Laurence, S.D.
119. Redfield, S.D.
120. Feeble Minded School
121. Conde, S.D.
122. Frankfort, S.D.
123. Vienna, S.D.
124. Willow Lake, S.D.
125. Bryant, S.D.
126. Huron, S.D.
127. Iroquois, S.D.
128. Wessington, S.D.
129. Wolsey, S.D.
130. De Smet, S.D.
131. Carthage, S.D.
132. Alpena, S.D.
133. Clark, S.D.
134. Doland, S.D.
135. Woonsocket, S.D.
136. Artesian, S.D.
137. Letcher, S.D.
138. Wessington Springs, S.D.
139. Mitchell, S.D.
140. Plankington, S.D.
141. Training School
142. Mt. Vernon, S.D.
143. Alexandria, S.D.
144. Ethan, S.D.
145. Parkston, S.D.
146. Spencer, S.D.
147. Emery, S.D.
148. Bridgewater, S.D.
149. Freeman, S.D.
150. Scotland, S.D.
151. Menno, S.D.
152. Montrose, S.D.
153. Howard, S.D.
154. Canova, S.D.
155. Salem, S.D.
156. Canistota, S.D.
157. Marion, S.D.
158. Parker, S.D.
159. Hurley, S.D.
160. Lennox, S.D.
161. Centerville, S.D.
162. Viborg, S.D.
163. Wakonda, S.D.
164. Vermillion, S.D.
165. Irene, S.D.
166. Volen, S.D.
167. Gayville, S.D.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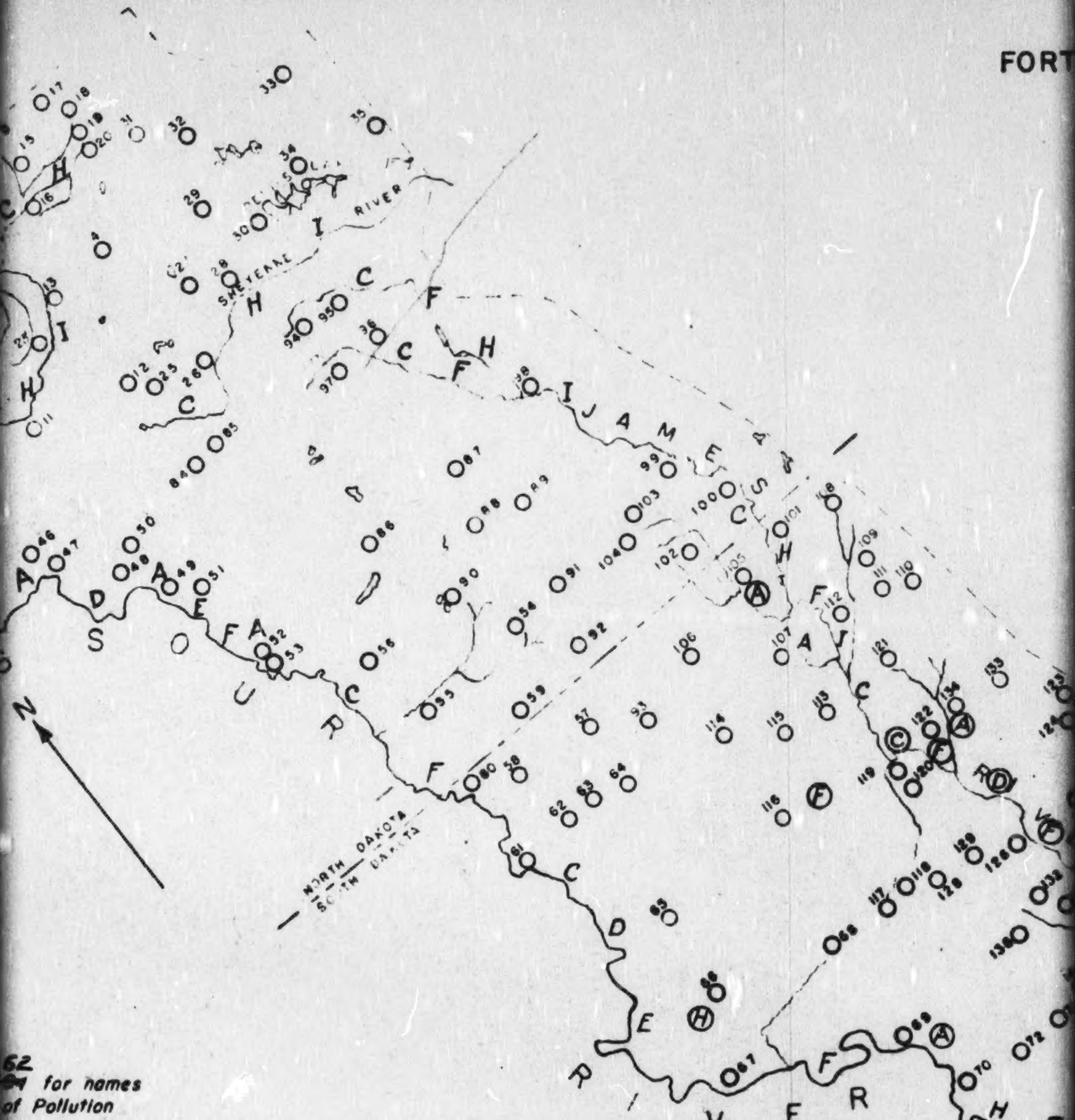
See pages ~~83~~ 61 and ~~84~~ 62 for names of Sources of Pollution

FORT



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SHEYENNE
RIVER
DEVILS LAKE
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R I V E R
NORTH DAKOTA
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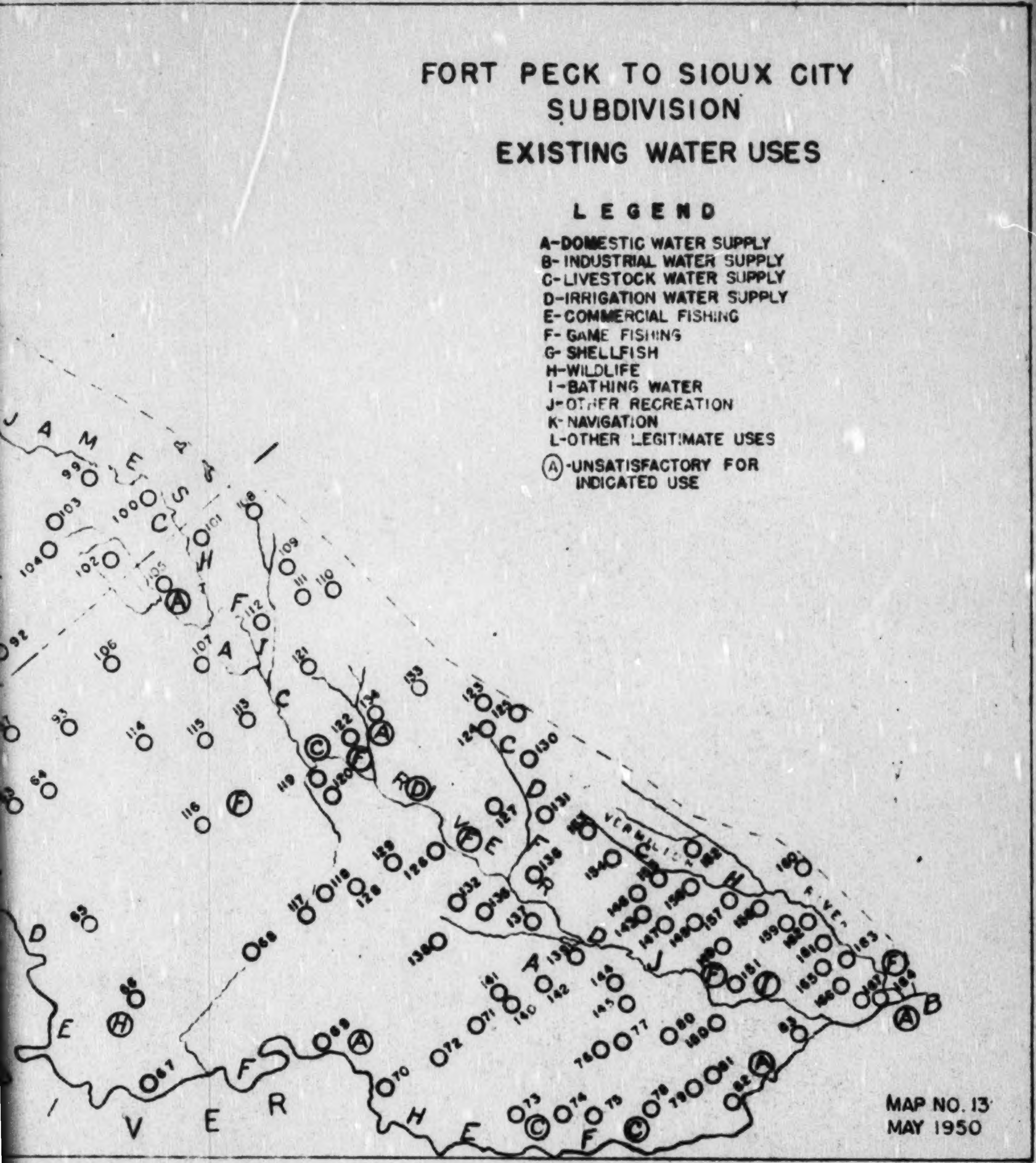
of Pollution



FORT PECK TO SIOUX CITY SUBDIVISION

EXISTING WATER USES

LEGEND

A-DOMESTIC WATER SUPPLY
B-INDUSTRIAL WATER SUPPLY
C-LIVESTOCK WATER SUPPLY
D-IRRIGATION WATER SUPPLY
E-COMMERCIAL FISHING
F-GAME FISHING
G-SHELLFISH
H-WILDLIFE
I-BATHING WATER
J-OTHER RECREATION
K-NAVIGATION
L-OTHER LEGITIMATE USES
Ⓐ-UNSATISFACTORY FOR INDICATED USE

MAP NO. 13
MAY 1950

MISSOURI RIVER BASIN

PART II

BENEFITS AND COSTS

The abatement of pollution in the Missouri Basin will (a) provide a source of domestic water supply free from excessive bacteria and organic material, (b) allow the waters of the Basin to be used extensively for recreational purposes with a minimum of hazard to the public health, (c) provide clean water necessary for the propagation of fish life and thereby greatly expand the income of the Basin from tourists and fishermen interested in the attractions thus provided, (d) remove or substantially decrease the probability that enteric diseases will be incurred by the use of vegetables and fruit grown on land irrigated by sewage-ladened water, (e) result in the removal of mineral or other inorganic contaminants such as oil field brines, acid mine wastes, and tailings from mining operations which now cause considerable loss to downstream water users.

Among the intangible benefits incurred by the improvement of the sanitary environment is the greater enjoyment of living, increased longevity, and increased production per capita, all of which are the results of improved public health.

The basic elements for water pollution control in the Missouri River Basin are sewage treatment and stream discharge regulation. Generally, a minimum of primary treatment is a requirement unless other downstream water uses or the normal mean minimum monthly flows are such that a higher degree of treatment is required. The relationship of sewage treatment and minimum sustained stream flows should produce stream conditions that will prevent public health hazards and sustain a balanced aquatic life. Normal minimum monthly mean flows are those flows that occur at such periodic frequencies as to form a firm base for treatment design.

The benefits resulting from water pollution control in the Basin are widespread. The public health is guarded as the result of water supply protection and improvement of the bacterial quality of irrigation water that may be dispersed on crops consumed raw. Nuisances are prevented and the general welfare of the public enhanced. Fish and wildlife conservation and recreational development is improved. In addition, improved water quality permits safe use for livestock watering and reduces navigation operation costs.

Closely related to the above discussion are benefits attributable to stream discharge regulation as a part of the development program for the Basin. The gigantic engineering plan calls for the completion of 138 reservoirs with a total water storage capacity in excess of 110 million acre-feet; the annual production of 11 billion kilowatt-hours of hydroelectric power; supplemental water for approximately one and one-half million acres of irrigated lands for which adequate water is not now available; the development of five million additional acres of irrigated lands; recreational facilities at numerous reservoirs, and an extensive program of soil conservation. The development, already 10 percent completed, will ultimately cost in excess of eight billion dollars.

Tangible monetary benefits to pollution control resulting from flow regulation may be evaluated in numerous instances. Where a lesser degree of sewage treatment will suffice, because of increased normal minimum mean flows, the reduced financial investment in the less complex treatment process as well as reduced operation, maintenance, and replacement costs represent sizeable savings. Annual values, based upon the life of the plant with current interest rates and including yearly savings in operation and maintenance, are readily obtainable. Fishery values may be appreciable as reflected by game and commercial species caught, not to mention expenditures related to the sport by ardent sportsmen.. Likewise reduced municipal and industrial water treatment costs may be significant.

In areas of existing critical water shortages, reservoir storage or sustained stream flows will provide an adequate, satisfactory water supply. Recreational areas may be developed where possibly none now exist. The development plan will permit recharging ground water storage in these areas by increasing stream flows, restoring lakes which have gradually disappeared during this century, and beneficially influencing water tables through percolation of water from canals, irrigated farms and small stream channels.

Water releases from impoundments of the development program of the Basin may have a finite value based upon water scarcity and use in the specific area. Sanitation and other benefits realized from a sustained low flow regulation program supplemental to the program of sewage and industrial waste treatment would be substantial, widespread, and interstate in character to the extent that regulated flows generally provide benefits to numerous communities and many diversified interests. Assessments of the recipients of their share of the benefits for the costs involved in the sustained low flow provision would be extremely complex and impractical. The problems involved are similar to those which would arise if the costs of flood control reservoirs were assessed against the beneficiaries. As the Congress in the Flood Control Act of June 28, 1938, and in subsequent legislation has recognized the impracticability of requiring local participation in the cost of flood control reservoirs, consideration should be given to a similar financial arrangement whereby the costs which may be allocated to procurement of widespread sanitations benefits from the development program may be borne by the United States. Such an arrangement would further water pollution control in the area and provide the citizens of the Missouri River Basin with substantial benefits not readily obtainable by other practical means. It should be fully understood that flow regulation is a supplement to, rather than a substitute for, sewage and industrial waste treatment.

The 270 new treatment works and the improvements needed at 166 existing plants, all of which serve municipal sewage systems, will cost approximately $50,000,000. The cost of providing facilities equivalent to primary treatment for industrial installations will be in the range of $15,000,000. The cost of treatment works and improvements needed, where present data is inadequate to determine the need, will probably be nearly $15,000,000 more. The total expenditure for sewage treatment, in both municipal and industrial waste, will be in the general range of $80,000,000 for the abatement of pollution in the Missouri Basin. The cost estimates for municipal treatment works are based on an analysis of construction costs of treatment works built in the last three years in Iowa and Nebraska. Industrial wastes treatment costs were based on the cost of providing lagoons for sugar refinery wastes, and of constructing wells for disposal of oil field wastes. Costs of treating other types of industrial wastes are based on costs of similar installations in other sections of the country.

Public health and sanitation considerations should be a fundamental part of development programs so that the important factors of health sanitation and well-being of the public receive proper attention in the planning phases of the projects. In this way the health of the people may be safeguarded against environment conditions related to the construction and development programs inimical to the best interests of public health.

MISSOURI RIVER BASIN

PART III

SPECIFIC POLICY PROBLEMS

Various Federal and State agencies are directly concerned with the water resources development program of the Missouri Drainage Basin. While it is clearly apparent that a conscientious attempt is being expended to eliminate overlapping and duplication of effort, certain policy problems are obviously present. However, these may be of less importance than expected because of the sincere efforts on the part of all concerned to effect a coordinated and comprehensive program for the Missouri Basin.

Specialized Problems Involving Project and Program Plans, Including that of Coordinating the Interest of the Several Agencies within the Basin

It is inevitable that the vast water resources development program now in progress in the Missouri Basin will effect changes in environment as related to health and sanitation. Promise is held for alleviation of water supply problems, not only as related to existing surface water supplies, but for certain communities which must now depend upon ground sources inadequate in quantity or unsatisfactory in quality. Promise is also held for alleviation of pollution problems where inadequate stream flows now make necessary a high degree of treatment. Sustained stream flows of increased volume may permit maintenance of satisfactory water quality standards with a lesser degree of sewage treatment.

On the reverse side of the ledger is the fact that in some instances stream flows will be reduced, requiring a higher degree of treatment. The clarification of streams resulting from impoundments, the retention of storage insured by these structures, and the added nutrient resulting from irrigation return flows will certainly result in algal problems at various water treatment plants where no such problems existed prior to the development program. The numerous impoundments and irrigation works will increase mosquito densities in and around these projects. Some of these mosquitoes are known to be vectors of human and equine encephalitis, others are of the pest variety important only as related to use of recreational facilities and the prevention of full and free use and enjoyment of property.

This general problem is exceedingly complex as related to the Public Health Service because the Service is not represented on either the Federal Inter-Agency Committee or the Missouri Basin Inter-Agency Committee. The Inter-Agency Committee has not as yet, therefore, proven to be an effective channel through which health interests may be coordinated with other interests. Maximum utilization of the development program for the improvement of environment as related to health and sanitation is the objective of official health agencies. To reach this objective, active consideration of projects in their planning stages is a basic essential. The few Federal agencies that are responsible for the administration of the development program in the Missouri Valley are so restricted by specific responsibilities, legislation and appropriations, that the inclusion of health objectives in the plan is extremely difficult. As a result, public health must compete with other interests of the development program, largely on a basis of anticipated monetary benefits. It is realized by all that benefits in terms of dollars of improved environment is extremely difficult to evaluate.

It appears that health implications of the development program are of sufficient magnitude and importance to justify representation of the Public Health Service on both the Federal Inter-Agency Committee and the Missouri Basin Inter-Agency Committee. Most administrators are aware of the many factors of environment which may directly or indirectly influence health and which are associated with the development and conservation of our land and water resources. These public health implications are not limited to any specific area but may be found wherever extensive development works have been or are being carried on. They were encountered in the Tennessee Valley, where at an early date a public health section was established as an integral part of the development and operating organization. The Missouri Valley is little different from other areas of the country except that its development program is more intensive at this time.

It seems logical that the water resources development program should be utilized to implement maximum development of the human resources of the area. The Public Health Service as the primary health agency of the Federal Government has not been able in any significant way to enter into the planning and development phases in a manner to insure the maximum health benefits to the people in the area. Action that has been possible include participation in the recent past in the invitation of the Missouri Basin Inter-Agency Committee to the Public Health Service for membership on the principal committee "Sub-Committee on Six Year Programs", and a formal agreement with the Bureau of Reclamation, Regions 6 and 7, regarding Public Health Service participation in the Missouri Basin Development Program.

The Missouri River Development Plan, while conceived and economically justified in terms of physical resources alone, holds promise for the provision of a more healthful environment as a secondary benefit. It is important that no significant health hazard be incorporated in any unit of the development plan, and that there be no cause for criticism of the Federal Government due to inadequate consideration of public health matters. This implies responsibility for the Public Health Service as the Agency of the Federal Government authorized to function in this specialized field of activity.

Resolution of Apparent Conflicts between Upstream and Downstream Interests in the Use of the Water Resources of the Basin

Irrigation, recreation, and fish and wildlife usage of surface waters is prevalent in the upstream areas of the major sub-basins. Generally a better realization of the need for sewage treatment in the upstream areas exists.

A major water use in the lower basin is that of dilution of sewage wastes. There is evidence of conflicting interests regarding releases of water for this purpose. Upstream interests feel that reasonable treatment of sewage wastes should be provided. Certain downstream interests are known to favor a sustained stream flow sufficient to make unnecessary any treatment of sewage discharged to the main stem. A sustained flow of this magnitude would seriously influence the adequacy of the entire supply for other considered purposes. Flows required for the navigation season are consistent with requirements for primary treatment of sewage and are already cared for in the development planning. Winter flows required for dilution of primary treated sewage will not seriously jeopardize the adequacy of the total supply for all purposes.

The Missouri Basin Inter-Agency Committee is cognizant of this problem and has assured fair consideration of downstream requirements for purposes of water supply and sanitation.

In some areas there appears to be competition between irrigation and sanitation interests. This is true primarily where available water is limited as compared to potential land for irrigation and where release of water for dilution of treated or partially treated sewage appears to be lost for irrigation purposes. Conversely, municipalities have long been using the flowing streams as vehicles for removing sewage wastes. Water required for this purpose can be reduced to a reasonable minimum by treatment of sewage.

It seems incumbent upon the development program to sustain stream flows compatible with the reasonable feasible limit of modern sewage plant capabilities, where flows of equal or greater magnitude have prevailed historically prior to the development program. It appears equally incumbent upon polluters to provide reasonable treatment of sewage wastes so that releases for this purpose can be held to a minimum.

Resolution of this apparent conflict is not impossible and progress is already apparent. Releases for sewage dilution have been included in the planning objectives for Harlan County Reservoir, and seem assured for at least 20 years under the most adverse anticipated climatic conditions. The State Water Pollution Control Agency of Kansas has issued formal orders for the construction of the abatement works upon which these flow requirements were based.

Conservation storage in many instances enhances recreational and allied interests over and above that possible with natural stream flow, particularly in the lower portions of the Basin. Improved water quality through storage and the resultant loss of turbidity will enhance fish life in the reservoir and in the regulated stream below which no fish life prevailed prior to the development. Boating, swimming, lake fishing and other recreational activities will be possible for the first time in certain areas where reservoirs are to be constructed.

In general, fish and wildlife interests are compatible with those of the water pollution agencies insofar as conservation, storage, and sustained stream flows are concerned. No significant conflict is believed to exist relative to the field of interest of this report.

Sediment Problems

Extremely high turbidity and accompanying problems of silt removal have plagued many water plants along the "Big Muddy" and its tributaries since these systems were first developed. The construction of 5 mammoth impoundments on the main stem, and smaller structures on important tributaries, will do much to reduce the silt load. Improved farming and soil conservation practices resulting from that portion of the development program carried on by the Department of Agriculture, are expected to further reduce silt pollution. As a result of the two forces, it is predicted that upon completion of the program, the Missouri River will be a relatively clear stream over its lower reaches.

Need for Mosquito Control Measures in and around Hydraulic Works

The creation of numerous impoundments and especially the development of extensive areas of irrigation will increase to a considerable degree the population of mosquitoes known to be vectors of disease, unless proper preventive action is taken.

Two important mosquito-borne diseases to be considered are encephalitis and malaria. At this time the control of these diseases is based largely upon the control of the vectors. If ideal mosquito breeding conditions are created, the control of these diseases may prove to be an extremely complicated and costly operation. On the other hand, as has been amply demonstrated, wherever proper preventive actions have been taken to minimize the creation of mosquito breeding situations, control operations have been simplified, materially reduced, or eliminated entirely. This is especially significant in the case of infectious human encephalitis and equine encephalomyelitis because of its widespread endemicity in the Basin.

In addition to the hazards of disease transmission, it should be borne in mind that the creation of mosquito nuisances will be unfavorable to recreational development and human welfare.

Need for Improved State Legislation Relating to the Control of Pollution

Water pollution control is closely related to water resource development. This is of particular significance in the Missouri Basin because of the wide range and repetitive uses made of our water resources, especially where water quality is of prime significance such as irrigation of truck crops, fish propagation, and domestic and industrial water supply. The Federal Water Pollution Act designates primary responsibility for abatement measures as a proper function of State Government. It therefore becomes of considerable importance that State statutes be sufficiently strong and comprehensive to enable an effective control program in the respective States.

Generally speaking, state statutes in the Missouri Basin governing the control or abatement of pollution are extremely weak when compared to other sections of the country. Of the ten States in the Missouri Basin, only two have strong and comprehensive legislation. Two States have virtually no legislation or controls in this field, and legislation in each of the remaining 6 States is weak. This is unfortunate inasmuch as a sound law is a powerful influence in securing remedial measures even though the legal machinery created by it may seldom be called upon to function. New or improved State legislation, with general uniformity throughout the Basin, would do much to accelerate abatement progress and permit suitable water quality for various water uses.